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AGRICULTURAL EDUCATION IN SCOTLAND.

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PART I.

AT the beginning of the eighteenth century Scottish agriculture was in a deplorable state. Seven years of the worst possible weather conditions—"King William's years," the Jacobites called them—resulted not only in famine and a terrible death-rate among the rural population, but also in a large extent of land going out of cultivation. Methods of tillage were of the most primitive description and no change had been made upon these for many generations. The mediæval mode of farming still in vogue was that of the infield and outfield system, in which only the infield was ever manured, the fertility of the outfield being supposed to be maintained by its being allowed to lie fallow for three or more years after three years cropping. The infield was cropped continuously with oats or bere; and to such an extent did this continuous cropping go that it was no uncommon experience for the yield to be little more than double or treble the seed.

Through lack of draining, low ground could not be tilled, and the bulk of the arable land was on hill slopes where alone comparatively dry soil was available.

Much of the land was divided on the "runrig" system in which the various tenants had their holdings in separate ridges indiscriminately located throughout the common field. Enclosures there were none, and each man's ridge was separated from his neighbours on either side by a "baulk" which was usually overgrown with weeds and briars. The "rigs" were redistributed by lot each year, and thus no individual holder had the least incentive to improve the condition of his holding.

The implements of husbandry were likewise of the most primitive type. The ploughs were huge unwieldy constructions of wood with coulter and share of iron; they were drawn by teams of oxen, sometimes twelve in number; and they required four men to conduct operations—one to hold the plough, one to lead the team, one to goad them on and one to "mend the land" in front of the plough. With all this array, the amount of ground tilled, or rather scratched, rarely exceeded half an acre a day; and even so, ploughing operations were seldom timeously begun, and

seeding did not take place till April, with the result that harvest was late and often suffered from bad weather in autumn. Threshing was done by the flail, and the corn was winnowed by being thrown in the air on the top of the "shillinglaw." Wheeled vehicles were not in use and produce was dragged in sleds or carried in creels by women or in panniers by horses.

When the fields were cleared, the cattle, which had till then been herded on waste or fallow ground, were allowed free run, and the undrained land was trampled and puddled by their hoofs. Green crops being unknown and the sowing of grasses unheard of, fodder was so scarce that the cattle were starved throughout the winter and had actually to be "lifted" into the pastures in spring.

Under the conditions described, there is little wonder that a bad season, much more a succession of bad seasons, brought famine and death into the land, and that even at the best the population lived a hand-to-mouth existence.

Improvement came from the south. After the Union of the Parliaments in 1707 inter-communication between the two countries became more common and Scottish lairds travelling through England could not fail to be impressed by the difference between the agricultural condition of their own country and that of some parts at least of the southern English counties. Credit for the first introduction of English methods of cultivation belongs to the Countess of Huntly—afterwards Duchess of Gordon—daughter of the Earl of Peterborough. The writer of the *Essay on Enclosing, Fallowing, etc.*, published in Edinburgh in 1729, says—"I remember on that lady's first coming to Scotland I heard she caused bring down English ploughs and skilful plowmen to fallow. I can trace that most useful and valuable operation no higher in Scotland than that excellent lady's coming among us . . . Scotland is indebted to the Duchess for right method of making hay, planting, laying out grounds for gardening and parterres . . . to enclose, drain and plant."

Several noblemen and gentry followed her example, and in 1723 at a meeting held in Edinburgh "The Honourable the Society of Improvers in the Knowledge of Agriculture in Scotland" was formed. The founders were moved by their sense "of how much the right husbandry and improvement of ground is neglected, partly through the want of skill of those who make a profession thereof and partly through the want of due encouragement for making proper experiments." The measures taken by the Society to further their aims were not heroic but they were eminently practical: sub-committees were appointed to deal with different sections of agriculture and were instructed "to mark down their thoughts thereupon in writing to be revised by the committee." They were "to correspond with the most intelligent in all the different customs in the nation concerning their different ways of managing their grounds, that what may be amiss may be corrected, and what is profitable imitated." The members of the Society were likewise invited "to send up the different ways of the

management of their farms and to form small societies of gentlemen and farmers in their several counties." Thus agricultural knowledge was to be collected and pooled for the benefit of the nation. Landowners and farmers were advised on their special problems, and it is interesting to find, among the recommendations made, suggestions for the ploughing in of a pease crop for manure, the cultivation of potatoes and flax, the growing of turnips, and the feeding of sheep on the turnips by field-sections enclosed by hurdles, the use of lime marl and the utilisation of seaweed as manure.

The Society's efforts were not confined to agriculture; they took steps also to encourage Scottish manufactures. Besides obtaining and distributing information about the manufacture of linen, they passed a resolution that "they themselves, their wives and children should buy no linen for shirting, wearing cloaths, bed-linen, table-linen or any other household furniture except such as were of the manufacture of Great Britain." Recommendations made by the Society led up to the institution of two public bodies which in their time have done much for the welfare of the country, the Board of Trustees for Manufacturers, established in 1727 and the Board of Fisheries constituted in 1809.

The two most active members of the society were the preses, Thomas Hope of Rankeilour, and the secretary, Robert Maxwell of Arkland. The former gave ocular demonstration of his agricultural capabilities by leasing from the City of Edinburgh the marsh then known as Straton's Loch, and draining and improving it into the pleasure ground now familiar as the Meadows. His house of Hope Park was a favourite meeting place for the society, in order that "having the pleasant prospect and the encouraging precedent in view, its zeal to promote agriculture might be more excited."

The secretary, Mr Maxwell, a scion of the well-known Kirkcudbrightshire family, took a lease of the farm of Clifton Hall, near Edinburgh, and there carried out experiments in improved husbandry. He compiled a record of the Society's operations and published this as the "Select Transactions" in 1743. The Society seems to have come to an end about that time; at all events it did not survive the Forty-Five Rebellion.

To the period covered by the Transactions belongs the publication of the *Essay on Enclosing, etc.*, already mentioned. The author, who is commonly believed to be Mackintosh of Borlum, one of the Jacobite leaders in the 1745 Rebellion, gives expression *inter alia* to his views on rural education. He is all for rural bias. In his opinion the Latin reading of the country boy should be the writings of those authors who deal with agricultural matters. He thinks a weekly discussion should be held with the pupils on points of husbandry, or breeding or fattening cattle. He tries to enlist the church in the service of agriculture, recommending ministers to set an example to their parishoners in the cultivation and management of their own glebes. He even

hints that the subject of agriculture ought not to be beneath the notice of the learned masters of our Universities. Truly an advanced thinker and a suggestive writer, well worthy of his self-chosen title—"a lover of his country."

We have seen that the method adopted by the Society of Improvers was in the main the distribution of knowledge and the giving of advice on agricultural practice. A different course was followed by their successors—the Edinburgh Society for Encouraging Arts, Sciences, Manufactures and Agriculture. This Edinburgh society was an offshoot of the Select Society, which body was in the nature of a mutual improvement association formed with the object of discussing philosophical and other problems and giving to its members opportunity for public speaking. Among the members—who were admitted on a strict ballot—were most of the famous literary men then resident in Edinburgh, and it is related of David Hume and Adam Smith, both members, that they never opened their lips.

The Edinburgh Society, formed within this parent association, was open to anyone contributing two guineas annually, the aim being to promote arts and manufactures by the proper distribution of premiums. In April 1755, a list was published of the objects for which premiums would be given, and of the somewhat miscellaneous items therein, the only one relating to agriculture was the award of a gold medal for "the best dissertation on vegetation and the principles of agriculture." A revised list issued in the same year offered a prize of £10 "to the farmer who planted the greatest number (not under 1000) of timber trees, oak, beech, ash or elm in hedgerows before December 1756, with a second award of £5 (not under 500); and another of £6 to the farmer who should rear the greatest number (not under 2000) of young thorn plants before December 1758, with a second prize of £4 for the next highest (not under 1000)." The gold medal for the dissertation was awarded to Dr Francis Home, physician in Edinburgh—not the only representative of that profession who has gained distinction in agriculture. In later years premiums were awarded for the best invention in arts or agriculture—won by Robert Mackail, millwright, for a machine to clean wheat; to the farmer who should keep the best stud stallion; to the farmer who should feed and sell to the butcher the greatest number of calves not under six weeks old; for best salt butter; for cow-milk cheese; for a dissertation on manures; for greatest quantity saved of rye-grass seed; for greatest quantity of potatoes brought to market on or before 20th August. These prizes for stock were probably the first awarded in Scotland, and the parade of stallions, both draught and saddle horses, on the second Wednesday of July 1759, was the forerunner of our modern shows.

Interest in the society gradually fell off. Difficulty was experienced in getting in the voluntary contributions. The last show of horses was held on the first Wednesday of August 1764, at Richard Vary's, near Hope Park, and the notice in the *Mercury*

states that "the horses and mares which competed for the premiums were more in number and in general much finer than those shown upon former occasions." In spite of this success the funds were not replenished satisfactorily, and the Edinburgh Society came to an end in 1765.

Whether owing to the influence of these societies or to a wider movement of which their existence was itself an evidence, the fact remains that the second half of the eighteenth century showed a wonderful change in the system and methods of Scottish agriculture. In many parts of the country the land was enclosed and drained, the old runrig system was given up, as was also the practice of infield and outfield; the swing-plough took the place of the old heavy implement; better varieties of cereals began to be used; green crops were introduced and "artificial" grasses were sown; by attention to breeding, cattle and horses were improved; the passing of the Turnpike Act in 1757 led to the making of roads on which wheeled vehicles could transport produce with comparative ease and cheapness; and the establishment of banks about 1760 supplied the monetary accommodation which was needed to carry these and other improvements into effect. A striking illustration of the cumulative result of the forward movement is the fact that whereas the rental of land in Scotland was estimated at £822,857 in 1748, it had advanced by 1813 to £6,285,500.

The suppression of the Forty-five Rebellion led to the opening up of the Highlands, where many of the estates were confiscated to the Government and sold or leased to men with capital, the old clan system came to an end, and newer methods of land management were introduced. The changes were not made without causing hardship, and the condition of the Highlands and Islands was matter for earnest thought among statesmen and landowners. It was, indeed, the condition of the Highlands in the second half of the century that led to the institution of the society which later became and still remains our national agricultural society.

Eighteen years after the disappearance of the Edinburgh Society it occurred to some gentlemen of the north and west that something might be done to ameliorate the conditions of life in the Highlands. Forming themselves into a committee, they communicated with a number of Highland lairds and invited them to attend a meeting in Edinburgh on the 9th of February 1784. The meeting duly held agreed to constitute the Highland Society of Edinburgh, and a general meeting held about a year later approved of the draft objects and constitution. The advancement of agriculture was only one of the aims which the society set before themselves and which were in 1787 embodied in their first Royal Charter.

To begin with, the procedure adopted by the society was mainly that of its predecessor, viz., the award of premiums for various endeavours, including the writing of essays on agricultural subjects, the growing of hay crops, turnips, potatoes and flax, and

the production of commercial cattle. Later, the award of premiums for agricultural projects was extended to implements and machines, land reclamation, irrigation, drainage, dairy produce, ploughing competitions and other more general matters. The idea of holding a show, first mooted in 1812, was carried into effect in December 1822, when the first show was held in Edinburgh, in the grounds of the Queensberry House, Canongate. With that event the activities of the society may be regarded as in full swing, and further note of these need not be made here except in so far as they refer to agricultural education in its more restricted sense. As we shall see, the Society has all along had a high sense of its duty in this regard and there have been few, if any, movements for the advancement of that side of Scottish agriculture, in which the Society has not played a leading part.

We have already seen that the general movement of which the formation of these societies was a notable indication owed much of its force to the interest and influence of the more educated and travelled portion of the community—the nobility, gentry, lairds, lawyers and clergy—who realised the need for increased production and who knew from experience of other countries or from their reading the possibilities of improved methods. Thus "Potato" Wilkie, the minister of Ratho, was more famous for his advocacy of the culture of that then little-known plant than for his "immortal" epic poem the *Epigoniad* or for his clerical ministrations; and Lord Kames, one of the "Fifteen" and author of the *Scottish Farmer*, deserves special mention as being indirectly responsible for the first beginning of academic teaching of agriculture. It so happened that in 1747 he was much taken up with the idea of applying chemistry to agriculture. He became acquainted with Dr Cullen who was then lecturing in chemistry in Glasgow University and who was afterwards appointed Professor of Chemistry at Edinburgh. On Lord Kames's solicitation Cullen gave some lectures on the science of agriculture and these may be regarded as the first formal teaching of the subject in the country.

Later, in 1788, Dr Walker, Professor of Natural History in Edinburgh University, gave a longer course of lectures on agriculture, under the patronage of the Highland Society who at their general meeting in January 1790, recommended their members to attend. Though the proposal for academic treatment of agricultural science had been made previously, and notably by Maxwell of Arkland in 1743, it was probably these courses that suggested the foundation of a university chair of agriculture to Sir William Pulteney—a Johnston of Westerhall, Dumfriesshire—who had married the heiress of the wealthy Pulteney family and had adopted their name. He it was who established the chair of agriculture in Edinburgh University and endowed it with the by no means princely income of £50 a year. He declined to make provision for an increased amount, his object being to cause the Professor "to exert himself and by no means to make the post a

sinecure." On 7th July 1790, he presented to the chair Dr Andrew Coventry of Shanwell, Kinross, a doctor of medicine who had acquired a reputation for scientific knowledge about agriculture. This reputation was strengthened while he held the chair and many agricultural projects were submitted to his judgment, such as the drainage scheme at Lochleven and the reclamation of the marsh-land there, which was carried out under his supervision. He published a synopsis of his lectures in 1808 and two treatises, one on the succession of crops and the valuation of soils, and the other on dairy produce; and he made two interesting suggestions to the Highland Society, *first*, that they should have a museum of specimens and models of pure breeds of farm animals, with accurate measurements; and *second*, that a teacher should be appointed to deal specially with live stock. We may note in these suggestions the germ of our modern stock-judging demonstrations and competitions, and the division of agricultural teaching into the two branches of crop husbandry and stock husbandry.

We are told that Professor Coventry's classes between 1790 and 1826, in which period he had delivered thirty-two courses, were attended by from thirty to seventy-eight students, a very creditable record seeing that the class did not qualify for graduation in any of the faculties. The students included farmers' sons, writers who had the management of estates, divinity students and others. From divinity students Professor Coventry never took a fee.

In later years other duties interfered with his lecturing and he gave his course only in alternate years, advising students to attend in the off-years the classes of chemistry and botany. This cutting down of his lecturing may have been the reason for the recommendation made by the Royal Commission of 1826–30 that the chair should be abolished unless a class could be provided for it and taught regularly. Fortunately this recommendation was ignored.

David Low, who held the chair from 1831 to 1854, was the son of an eminent land agent in Berwickshire and previous to his appointment he had gained some reputation as an agricultural journalist. His main contributions to the advancement of his subject were the formation of an agricultural museum; the collection of portraits of the best specimens of the different breeds of British farm animals, which is still in the possession of the University; and his books on *Practical Agriculture*, *Breeds of Domesticated Animals*, and *Landed Property and the Economy of Estates*.

John Wilson, 1854–1885, is best remembered as the author of *Farm Crops*, long a standard work.

During the tenure of Robert Wallace, 1885–1922, the degree of B.Sc. in Agriculture was instituted in 1892. This was the first agricultural degree in Britain and it has had the effect of raising the standard of agricultural teaching to a new level. Professor Wallace's *Farm Live Stock of Great Britain* has had a deservedly wide circulation. The recent appointment of his successor,

Mr J. A. Scott Watson, is of good augury for the continued reputation of the chair. As regards its emoluments a change was made in 1868 when the Highland and Agricultural Society offered to subscribe £150 annually on condition that a like sum was given from Government funds. The Government grant was obtained and this arrangement was continued till 1893 when the increased grants to the University from public funds, made on the recommendation of the Universities Commission became available.

Curiously enough, the chair at Edinburgh had just been established when provision was made for a lectureship in Aberdeen. In 1790 Sir William Fordyce, Rector of Marischal College, bequeathed to that institution £1000 four per cent consolidated bank annuities to pay a lecturer in agricultural chemistry and natural history. The will, however, gave the life-rent in this fund to the testator's sister-in-law and her daughters, and thus it came about that the bequest did not become available for the establishment of the lectureship until 1836. In 1840 regulations were drawn up and the first lecturer was appointed to hold office for three years, at a salary of £40 per annum. According to the terms of the bequest the lecturer was to deliver twelve lectures annually on such subjects as belong thereto [*i.e.*, to agricultural chemistry and natural history as related to agriculture] in the Public Hall of the said college once a year, for ever, at any season of the year that the Principal or Professors shall judge best, recommending an examination of all the earth's minerals and metals found in the County of Aberdeen in the beds of rivers, rocks, etc., that are likely to be of public use. Up to the year 1895, when a change was made in the conditions of tenure, the lectureship was held by—1840, John Shier; 1845, Professor Andrew Fyfe; 1848, John Smith; 1853, James Smith Brazier; 1862–74, Dr Thomas F. Jamieson; 1875–95, Thomas Jamieson (*secundus*).

Besides the founding of the Chair at Edinburgh and the Lectureship at Aberdeen, other events deserving of notice marked the closing years of the eighteenth century. Although possibly not having a very direct bearing on the forward movement in Scottish agriculture, the publication of the *Old Statistical Account of Scotland* is not without interest. About 1790 Sir John Sinclair sent out to every parish minister a series of questions designed to elicit information on all aspects of parochial life and industry. The replies to these questions, together with much useful statistical data gathered by Sinclair himself and his assistants were compiled and issued in twenty-one volumes from 1791 to 1799. From the agricultural point of view the account must have had considerable influence merely by bringing together descriptions of methods and customs practised in different parts of the country, and so instituting comparisons which would tend to stimulate the backward.

While still engaged in this compilation, Sir John was, in 1793, appointed by Pitt to be President of the first Board of Agriculture,

having as his colleague in the secretaryship the famous agricultural writer, Arthur Young. One of the first tasks undertaken by the Board was the carrying out of an agricultural survey of the English counties, six of the surveys being made by Young himself. One other instance of the Board's activities may be cited. We have already seen that as early as 1747 Lord Kames in Scotland was interested in the application of chemistry to agriculture. This was also the main theme of Francis Home's *Treatise on the Principles of Agriculture and Vegetation*, published in 1757. In 1802 the Board of Agriculture invited Humphrey Davy, then at the beginning of his fame as a chemist, to give a course of lectures on the "Connection of Chemistry with Vegetable Physiology." These lectures were given in ten successive years, and in 1813 Davy published his *Elements of Agricultural Chemistry*, which was the foundation of future work in this line of science.

The severe agricultural depression of the post-Napoleonic years led to the dissolution of the Board in 1822.

The geological side of agricultural science came into prominence about this time, and in the years between 1833 and 1843 a number of geological surveys and reports appeared in the *Transactions* of the Highland Society. The Society in 1834 obtained a new charter, extending its operations and altering its style and title to that by which it is still known—the Highland and Agricultural Society of Scotland.

The researches and writings of Liebig, the great German chemist, had the effect about 1840 of reviving interest in agricultural chemistry, and a notable example of this was the formation in 1843 of the Agricultural Chemistry Association, instituted by a few Midlothian farmers, the chief promoter being John Finnie, of Swanston. The Association appointed Professor Johnston, of Durham University, to be their chemist, and in the Society's *Transactions* he published numerous papers under the heading of "The Proceedings of the Agricultural Chemistry Association." The Association came to an end in 1848, when its functions were taken over by the chemical department of the Highland and Agricultural Society, who continued the appointment of a consultant chemist, first in the person of Dr Thomas Anderson, later of Mr James Dewar—afterwards Professor of Chemistry at Cambridge—and of Dr Andrew P. Aitken, who was a pioneer of the now universal practice of field experiments. Dr Aitken was followed in 1905 by Mr James Hendrick, who became Strathcona-Fordyce Professor in Aberdeen in 1912, and was succeeded by Dr J. F. Tocher, the present holder of the post.

The growing interest in agricultural education was shown in 1856 by the Highland and Agricultural Society's petitioning for a supplementary charter to enable them to direct and promote the education of young agriculturists by drafting a curriculum of study, holding examinations thereon, and awarding diplomas to successful candidates. The first examination was held in 1858. The subjects

of examination were:—Agriculture (Science and Practice), Botany, Chemistry, Natural History, Veterinary Science, Field Engineering and Book-keeping. By a later provision, passed in 1872, those who gained the diploma became eligible for election as life members of the Society. The examination continued to be held yearly until 1898, when the Society and the Royal Agricultural Society of England agreed to combine their examinations and diplomas. A Joint Examination Board was set up, and the new award was entitled the "National Diploma in Agriculture." On the Joint Board there are now, besides the delegates of the two constituent Societies, representatives of the Ministry of Agriculture and Fisheries, the Scottish Education Department and the Board of Agriculture for Scotland. The Joint Board has also since its institution conducted examinations in the science and practice of dairying for the "National Diploma in Dairying." The examinations in agriculture take place annually at Leeds in April, and those in dairying at Reading and Kilmarnock in September.

A similar scheme of examination for certificates in forestry has been in operation under the Highland and Agricultural Society since 1870.

Soon after the institution of these examinations for diplomas, it became apparent that more was wanted by the young agriculturist than mere guidance on lines of study, and examination thereon. There was an obvious lack of provision for direct teaching leading up to examination, as, apart from the agriculture class in Edinburgh and the lecture course in Aberdeen, facilities for systematic instruction were awanting in Scotland in the early years of the scheme. For some years, from 1866 onwards, a certain amount of general and applied science teaching had been given in schools throughout the country, under the stimulus of grants made by the Science and Art Department, South Kensington. But no special agricultural course was included in the Department's syllabus until in 1875 the Highland and Agricultural Society memorialised the Department to that end. The suggestion was favourably received, and in 1876 the Department issued a syllabus of instruction drawn up by Professor Henry Tanner, the examiner, who also published text-books on the subject.

The scheme of agricultural teaching thus introduced embraced three stages (1) that of the elementary school, (2) that of the evening school, and (3) that of special courses of a more advanced type. In the first two cases the instruction was given by the elementary teacher, and the pupils were examined at the annual school examination by H.M. Inspectors, the subject of agriculture being included in the list of so-called "specific" subjects for which special grants could be earned—at the rate of four shillings for each individual pass. In the third case, instruction was given with the object of preparing pupils to sit the examinations of the Science and Art Department, which granted certificates in three grades—Elementary, Advanced and Honours. While no special

qualification was insisted upon in the case of teachers giving instruction in the specific subject group, it was laid down that only those were qualified to give instruction for any of the three grades of Science and Art examinations who themselves had passed first-class in the Advanced Grade, or who otherwise were able to satisfy the Department of their fitness. Candidates for the Science and Art examinations were required to attend a course of at least twenty lectures. The examinations were held at various local centres—the papers being sent up to South Kensington—and grants of £1 to £3 were awarded for each pass according to the standard of proficiency attained.

In order to encourage further this teaching of agricultural science in schools, the Highland and Agricultural Society, at the same time as they memorialised for the introduction of agriculture into the Science and Art Department's list, offered a premium "for the best text-book for such a course, including the application of Botany, Geology, Chemistry and Physiology to the Art of Agriculture and the Management of Farm Stock," and in 1876 the premium of £25 was awarded to Mr Richard Henderson, Crosslanes, York.

The Society likewise offered bursaries to schools where agricultural science was taught. To the best pupils who had completed the school course ten bursaries of £20 were available to enable them to pass on to the University for a year's study of agricultural science there; while ten younger pupils might obtain a bursary of £10 to encourage them to attend school for an extra year. The Society's first bursary examination was held in 1875 when Alexander Sutherland, Watten, Caithness, was awarded a bursary of £20. The offer of bursaries ceased in 1892.

The operation of a scheme of instruction intended to be so general as this teaching of agricultural science in country schools was bound to call for some special training on the part of the teachers. Mere preparation from text-books—even those hall-marked by a premium—cannot take the place of a thorough knowledge and systematic training on the part of the would-be instructor. Thus it came about that facilities had to be provided for teaching the teachers. The general science courses at South Kensington were available, but something more direct was wanted, as well as something nearer home. At Aberdeen, from 1877 onwards, the courses given by Mr Jamieson, the Fordyce lecturer, were attended by teachers in rural schools, and grants were made by the Privy Council in aid of this work. About 1880 also, arrangements were made whereby students in attendance at the Aberdeen Training Colleges for Teachers might include Mr Jamieson's classes of agriculture and chemistry in their curriculum. There appears, indeed, to have been at first a much greater demand for agricultural science teaching in the north-eastern counties than in other parts of Scotland, as is shown by the fact that in 1878 all the grants paid for agricultural instruction in Scotland were, as stated in the Department's report

for that year, given to schools in these counties, and mainly in Aberdeenshire. It is possible that the effect of the Dick bequest in supplement of the salaries of schoolmasters in that district, was to settle there a type of teacher better qualified and more willing to undertake this extra work than was the case elsewhere. At all events, one of the reasons advanced for urging the Highland and Agricultural Society to take action for the recognition of agriculture was a signed undertaking on behalf of 150 schoolmasters in these northern districts that they were willing to teach the subject if recognition were granted. As showing the extent to which agriculture was taught under the Science and Art Department's scheme, it may be mentioned that, in 1877, 800 pupils were presented, and in 1878, 1265.

Later, classes for schoolmasters were provided in Edinburgh in September 1888, and at Glasgow in the winter session 1888-89, and for these also grants were derived from Government sources. The first attempt at setting up a teaching centre at Glasgow was made by Mr Primrose M'Connell, an Ayrshire man, who had attended Professor Wilson's agriculture class in Edinburgh. Along with Principal M'Call, of Glasgow Veterinary College, Mr M'Connell, in 1880, issued the prospectus of a Glasgow Agricultural College, the classes of which were to be held in the Veterinary College, Buccleuch Street, the agricultural instruction being given by Mr M'Connell, and other subjects by members of the veterinary staff, while practical demonstrations were offered on Principal M'Call's farm at Cambuslang. The course of instruction was adapted to the syllabus of the Highland and Agricultural Society's diploma, and included, besides agriculture, general and agricultural chemistry, botany, natural history, veterinary medicine and surgery, surveying and farm accounts. This combination of agricultural and veterinary teaching was again to be mooted at a later date. Mr M'Connell's venture did not succeed; the Glasgow Agricultural Society did not countenance it, and disappointed at this lack of support, Mr M'Connell followed his father to Essex, and turned his attention to farming, though later he returned to Edinburgh and graduated B.Sc. in 1889. He has the credit of being the first in Scotland to offer a full course of agricultural instruction, and his effort deserved a better fate.

In the winter of 1882-83, Mr Malcolm Finlayson, a native of Caithness, and a diplomé of the Highland and Agricultural Society, gave a course of lectures on agriculture in connection with the Young Chair of Technical Chemistry, a foundation established by Mr Young, of paraffin fame, for the teaching of industrial chemistry. The second session of Mr Finlayson's class failed for lack of students, but his venture was followed in 1886 by that of Mr R. P. Wright,[1] who also taught under the patronage of Professor Mills, the holder of the Young Chair. Mr Wright had

[1] Afterwards Sir Robert P. Wright, first Chairman of the Board of Agriculture for Scotland.

also been a student of Professor Wilson's, and was now engaged in farming in South Ayrshire. The emoluments of the agricultural teacher were then somewhat meagre. He had a class-room provided for him, but otherwise he was dependent upon his class fees and grants earned under the Science and Art Department's scheme. The Young Chair as a separate institution came to an end in 1887, being amalgamated with other Glasgow institutions into the teaching body now known as the Royal Technical College. A tentative arrangement to transfer the agricultural teaching to the Veterinary College was dropped at the instance of the Technical College Governors, and Mr Wright accepted an appointment as lecturer under that body. Thus was definitely established the third centre of agricultural teaching in Scotland, and it was in connection therewith that the special class for schoolmasters already referred to was held.

As to Edinburgh, when Professor Wallace took up the duties of the chair in 1885, there was no provision for agricultural students obtaining instruction in the sciences as applied to agriculture. Many of them, to their credit be it said, took the ordinary classes in such subjects as chemistry, botany, geology and natural history, but none of these were taught with any special reference to agriculture. Professor Wallace at once set himself to remedy this defect by getting certain extra-mural lecturers to combine with himself in providing a course of agricultural science. In 1892 this body of lecturers was formed into the Incorporated School of Agriculture, with a Board of Directors—public men interested in education and agriculture—and with an offer of a course of study in agriculture, chemistry, botany, zoology, veterinary science and book-keeping, the classes being held in the University, Minto House, the New Veterinary College and in private class-rooms. An evening class in agriculture was begun in 1888; it was held in the Heriot-Watt College, where also in later years other evening classes, *e.g.*, that in horticulture, were made available.

The avowed object of the incorporation of the school was to establish a body to which Government grants could be made payable and one of the first fruits was a grant of £300 from the Privy Council Committee to meet expenditure on special classes in agricultural science for schoolmasters. Selected teachers were given a grant covering railway fare and maintenance allowance for four weeks attendance on a vacation course in agriculture and chemistry, and a further grant in subsequent years was applied in providing teaching equipment in the shape of maps and books. The course was highly popular for several years, the grant being continued by the Board of Agriculture.

This second Board, set up in 1889, gave official recognition to the three teaching centres of Edinburgh, Aberdeen and Glasgow. Previous to that year a department of the Privy Council had been entrusted with the administration of agricultural affairs, and this body made certain grants in aid of agricultural teaching. It may be interesting to quote the allocation made in their last year of

office by the Lords of the Committee of Council for Agriculture, so far as these relate to Scotland. They were :—

Edinburgh University, Teachers' Classes	£300	
Glasgow and West of Scotland Technical College, Agricultural Education	200	
Glasgow and West of Scotland Technical College, Teachers' Classes	50	
Stewartry Dairy Association, Cheese-making Instruction	70	
Ayrshire Dairy Association, Cheese-making Instruction	125	
Wigtownshire Dairy Association, Cheese-making Instruction	101	10s.
Dumfriesshire Dairy Association, Cheese-making Instruction	28	10s.
Dounby Science School, Orkney, Agricultural Experiments	25	
Aberdeenshire Association, Agricultural Experiments	50	
Heriot-Watt College, Edinburgh, Agricultural Lectures	100	
Institute of Scottish Teachers of Agriculture, Library, etc.	100	
Aberdeen University, Agricultural Instruction	100	
Scottish Dairy Institute, Kilmarnock, Salaries of Teachers	50	

It will be noticed that dairying instruction is a special object of grants. This branch of formal agricultural teaching had first been taken up in Ayrshire to which county about 1860 a number of landlords had brought Mr and Mrs Joseph Harding from Somersetshire to instruct their tenantry in the making of cheese; and in 1884 for the same purpose a Mr Harris was brought over from Canada on the initiative of Mr Andrew Clement, a Glasgow cheese merchant of great business acumen and energy, who had himself been in Canada, and who recognised the need for instruction of the Scottish cheese-maker in order to secure improvement and uniformity of product. Mr Harris was followed from Canada in 1885 by Mr R. J. Drummond who has since done yeoman service in improving the product of our dairy farms. The instruction was at first peripatetic, but finally Mr Drummond was settled with a permanent equipment at Holmes Farm, Kilmarnock, in 1889; and thus we find in the list quoted above, both the peripatetic and the permanent types of dairying instruction as recipients of Government grants.

The allocation of grants for agricultural experimental work is also worthy of notice as showing the beginnings of that highly useful type of agricultural teaching by practical demonstration.

The newly constituted Board of Agriculture soon after taking

over the administration of these and other funds, grouped the provisions made for agricultural education as under:—

1. The training of agricultural teachers, qualified alike by scientific knowledge and practical experience, and the providing of facilities for the acquisition of agricultural knowledge by elementary schoolmasters.
2. The imparting of direct education in the sciences bearing on agriculture to resident pupils taking courses of study in schools or in collegiate institutions.
3. The diffusion of general knowledge and the promotion of a spirit of intelligent inquiry among those already engaged in agricultural work, by means of peripatetic lectures and evening classes.
4. The technical training either of pupils or of actual workers in special forms of agricultural industry, such as dairy work, forestry or fruit-growing.
5. The conduct of experimental work, affording in different centres means of illustrating the bearing of scientific research on customary agricultural practice.

In carrying on their administration and assisting these various lines of activity, the Board deliberately set themselves to encourage the development of teaching centres whose spheres and operations would cover a fairly wide area. The declared object of this policy was to secure at each provincial collegiate centre a combination of all the several forms of agricultural instruction above detailed into one complete and organised system.

The need for the steady pursuit of such a policy was urgent in view of the situation which arose in 1890, brought about by the passing of the Local Taxation (Customs and Excise) Act of that year. An addition to the taxes on excisable liquors was intended to be applied to compensate holders who had been deprived of their licences through reduction in the number of these. The outcry raised against this proposal caused the Government to divert the produce of the additional taxation elsewhere, and the Act of 1890 handed over to the lately constituted County Councils the funds so derived—hence vulgarly called "Whisky Money"—with no more direction as to its application than that it might be applied either in relief of local rates or in support of technical education, or partly to both. In most instances County Councils referred the problem of assisting technical education to the Burgh and County Secondary Education Committees established in 1893, and as their schemes had to be submitted for the approval of the Education Department, a means was thus provided whereby some degree of uniformity might be attained. The powers of the Education Department were extended in 1896 to take in agricultural instruction, an arrangement being made that the administration of grants in aid should be transferred from the Board of Agriculture to that Department.

Thus in that year the position in Scotland was that (1) the Education Department was in control of the Government funds

that might be applied to agricultural education; (2) the County Councils had at their disposal the residue grant which might in part be applied to the same object; (3) there were three recognised centres of general agricultural instruction and one permanent centre of dairying instruction, viz., Edinburgh, Aberdeen, Glasgow and Kilmarnock; (4) there was a certain amount of county extension work being carried on, mainly in dairying instruction; (5) a beginning had been made in experimental and demonstration work.

The further developments in these lines will be more appropriately dealt with in giving some account of the constitution and the activities of the three Agricultural Colleges which have since been established; other branches of education, viz., those of Veterinary Medicine, Forestry, Horticulture, etc., are reserved for separate notice.

It is fitting, however, that acknowledgment should be made in this place of the services rendered to agricultural advancement by the agricultural press.

From 1800 to 1824 *The Farmers' Magazine* was published quarterly, for most of the time under the editorship of Mr Brown, tenant of Murkle, East Linton, and this was followed by *The Quarterly Journal of Agriculture.* These, however, and likewise the *Transactions* of the Highland and Agricultural Society, were restricted in their circulation among farmers, and it was not until a monthly magazine—*The Ayrshire Agriculturist*—appeared in Ayr in 1843 that the needs of the general farming community began to be met. In 1849 this venture was transferred to Edinburgh as a weekly journal and rechristened *The North British Agriculturist*, under which title it has continued to be published, latterly by the Messrs Anderson, and edited in turn by such well-known men as Mr William Macdonald and Mr David Young.

The Scottish Farmer, launched in Glasgow in 1893, has attained a wide circulation under the able guidance of Mr Archibald M'Neilage; and a third venture, *The Farming News*, has for some years been issued by the Munro Press, Perth.

All of these publications, in addition to supplying their readers with information on the business side of farming and taking an active share in agricultural politics, have proved themselves admirable agents in the dissemination of the knowledge of agricultural science.

THE ROWETT RESEARCH INSTITUTE.

J. B. ORR, M.A., D.SC., M.D., *Director.*

DURING the latter half of the nineteenth century, scientific research and its application to industry led to revolutionary changes in the industrial world. Agriculture, however, far from sharing in the general advance and prosperity, experienced—owing to a variety

of well-known causes—a period of serious depression. There was little inducement for the farmer to experiment with new methods, and from 1850 to 1900 the only important change he made was to follow the example of the manufacturing industries in the introduction of labour-saving machinery.

With the notable exception of the private enterprise at Rothamsted, where investigations had been carried out chiefly in connection with arable farming since 1843, there was no organised attempt to apply to agriculture the information being discovered by science. In stock farming, though prominent breeders were most successful in improving breeds in selected herds, the average commercial animal was not greatly improved, and with regard to feeding, the only change of any importance was the increased use of various industrial by-products in the form of meals or cakes for winter feeding, and these were popularised by the self-interested activities of the manufacturers and merchants.

This relative inertia in agriculture which existed in Britain was a contrast to the progress being made in some other countries, notably in Germany and America, where national schemes of agricultural research were being carried out, and in Denmark and Scandinavia, where rapid progress was being made in the improvement of methods, and in organising the industry to give increased production and a better return to those engaged in it.

Development Commission Scheme of Research.—A great stimulus to agricultural research in Britain was got from the Development Commission, which was established in 1911. The Commission was appointed with the object of developing rural industries. The Commissioners, after enquiry and consideration, decided that a national scheme of research in agriculture was essential for the improvement of these industries. The main feature of the scheme which they evolved to meet the situation was the proposed establishment of several institutes, each of which would carry out investigations in one branch of agricultural science.

Several institutes were founded before the outbreak of war. In some cases, as at Rothamsted and at Cambridge, advantage was taken of existing research organisations which were assisted financially aud developed. In other cases new institutions had to be established. Owing to the nature of the subjects to be studied, some of the institutes require several years to develop, and, unfortunately, the work, shortly after it had begun, was arrested by the outbreak of war. It will be some years before the full benefits of these institutions become apparent. Even at this early stage, however, the results that have been obtained, some of which are already being applied in practice, show that the researches of these institutes will have a powerful influence in improving agriculture.

So far as Scotland is concerned, it is only since the war that the work of developing research institutes has made any progress. Work in connection with the Rowett Institute was begun in April 1914, but was in abeyance during the whole period of the war.

The other research organisations in Scotland that arose out of the Development Commission scheme have originated since the war.

Establishment of the Rowett Institute.—As the outcome of negotiations between the Development Commission, the Board of Agriculture for Scotland and the North of Scotland College of Agriculture, it was agreed in 1913 that an institute for research in animal nutrition should be established in Aberdeen under the supervision of a Joint Committee appointed by the Governors of the College and the Court of Aberdeen University. The work of establishing the institute was delayed by the war, and it was not until 1919 that the Joint Committee secured the approval of the Development Commission and of the Board of Agriculture to the arrangements and plans which they had made for developing the institute.

The amount of the initial capital outlay was estimated at £40,000 to £50,000, and of this sum £20,000 was obtained from the Treasury on the recommendation of the Development Commission. Towards the rest of the required funds, Dr John Quiller Rowett generously subscribed £10,000, and promised a further contribution if necessary. Later, when there was difficulty in obtaining a suitable site for the institute, he provided the committee with the funds necessary to purchase the farm on which the new buildings have been erected. Had it not been for the public-spirited action of Dr Rowett, the establishment of the institute might have been delayed, probably for years, for lack of funds. Not only agriculturists, but all interested in food production and in the prevention of nutritional diseases both in man and in farm animals, owe him a debt of gratitude.

Dr Rowett's contribution was at first anonymous, but the committee decided, with the approval of the Board of Agriculture, that the institution should be named "The Rowett Institute," in recognition of the assistance it had received from a generous benefactor, who, fortunately for agricultural science, was able to appreciate the potential value of the research work even before it had begun.

The erection of the buildings required for the institute was begun early in 1921. On 12th September 1922 they were formally declared opened by Her Majesty the Queen, who was accompanied by the Duchess of Atholl, the Duke of Richmond and Gordon, the Chancellor of Aberdeen University, and her suite. The opening ceremony took place in the library of the Institute, in the presence of a company of about 200, consisting chiefly of representatives of public bodies and agricultural societies.

Work of the Institute.—The chief work of the institute consists of carrying out investigations to get information that will enable animals to be fed and handled so as to produce the maximum amount of human food with the minimum cost. These investigations are much more complicated and difficult than the uninitiated would imagine. If an animal is to be kept in perfect health and to grow at the maximum rate, its food must not only be of such

a nature that it will be relished and easily digested, but it must contain all the constituents essential for nutrition in the proportion required: the necessary amino acids (the constituents of proteins), the different minerals, fats, carbohydrates and probably other unknown substances must be present. There are over thirty substances known to be essential to growth and health. If all these could be given in exactly the proportion required, then there would be perfect utilisation of the food, maximum production and absence of nutritional disease.

At the present time we have only scanty knowledge of how much of each is required for different animals, and how much is present in different feeding-stuffs. Fortunately, they are all present to some extent in most feeding-stuffs, in the natural condition at least, and consequently the various mixed rations that have been found suitable in practice contain sufficient of all the essential constituents to enable the animal to live and serve the purpose for which it is fed. But the best return is not got for the food used. Most ordinary mixed rations contain much more of some constituents than are needed, and consequently there is wastage of the excess. On the other hand, the rations frequently contain too little of one or more of the essential constituents, and deficiency of them prevents the full utilisation of the ration, and in many cases makes the animal more susceptible to disease.

In the present method of compounding rations, attention is paid to the amount of protein present, and to the energy or "starch value" of the ration; but little account is taken either of the need of the animals for food substances other than proteins, or to the supply of them in the different feeding-stuffs used. It is not to be wondered at, therefore, that there is a perfectly enormous wastage of feeding-stuffs, and that conditions of malnutrition are so prevalent.

In a state of nature, the pasture gives the animal all the substances necessary, and mothers grazing on good pastures supply in their milk the perfect food for their young. Under modern intensive conditions, however, this natural condition of affairs is upset. Artificial feeding-stuffs have been introduced, and animals with artificial needs have been evolved. Nature never intended a hen to lay 300 eggs per annum, or a cow to give 3000 gallons of milk in a lactation period, or a calf to be half a ton in weight within a year; nor did she intend that the animal would be fed in confinement on artificial foods that had been subjected to manufacturing processes which remove or destroy much of their nutritive value. These modern conditions intensify the difficulty of the problem, not only of feeding farm animals, but of keeping them free from disease and sterility.

The fundamental problems of animal nutrition are connected with (1) the requirements of animals in respect of the essential food constituents, and (2) the amounts of them present in the feeding-stuffs available. When these are known, the way is open

to adjust rations to the needs of the animal, so that the maximum utilisation will be obtained.

The difficulties of the work are sufficiently obvious. No matter at which corner of the field work is begun, it is no sooner started than the physiologist is required to investigate the need for the different constituents of food, the influence of deficiency or excess of one constituent upon the utilisation of the others, the problem of digestion of the food and the availability of the constituents present in the ration. The chemist is needed for the analysis of food-stuffs, and for the metabolic work in which animals are placed in specially constructed cages, so that the urine and fæces can be accurately collected and analysed so that everything that goes in to the animal, and everything that comes out can be determined. The bacteriologist is needed, because in the ruminant, one essential part of digestion is carried out by bacteria in the first stomach. The pathologist is needed for the examination of the organs and tissues of the animal to find out what effect various methods of feeding have upon these. The problems are so complicated and involved that, before any line of investigation can be carried out for any length of time, all these scientists must be called in, each to deal with the problems that arise in their special branch of science.

There is another side of the work that is much more straightforward. There are many practical problems in animal nutrition that can be investigated and may yield results which, though leaving the deeper problem unsolved, are of immediate value to the farmer. For instance, metabolic and feeding experiments can determine the relative nutritive value of different feeding-stuffs when added to certain rations, as, for example, the relative value of silage and turnips for growing animals or for milk cows. These experiments, however, give information of only limited application, because the value of any given food-stuff depends upon the rest of the ration. A pound of a certain kind of cake, when added to a given ration, might be more valuable than an equal quantity of the dry matter of silage. With a different ration, however, the cake might be superfluous and practically useless, whereas a small amount of silage might supply the deficiency of the ration and so increase the percentage availability of it. Nevertheless, there is much work of this kind that requires to be done, and some of these practical experiments would, if successful, throw light on many problems that are of immediate economic importance.

In carrying out research in animal nutrition there are two extremes that must be avoided. The need for practical experiments to get information which is capable of immediate application even locally or in particular instances is so great that there is danger of exclusive devotion to this work. The danger is increased by the fact that it has the sympathy and support of the farmer, who, indeed, is himself trying to solve the same problems, and has a fund of experience and information available to assist with the work. Unless the experiments, however, are based upon and

guided by the results of fundamental research work, they tend to become sterile, and degenerate into tests of such a nature that the well-informed farmer can predict the result.

On the other hand, workers dealing with problems in what may be called pure science, find it almost impossible to resist the temptation to follow the lead given by the results they obtain and to pursue the truth, even though it may lead them to the study of problems which are of purely academic interest, and never likely to have any practical bearing in agriculture. The field is so wide and the problems of fascinating interest that call for solution are so numerous, that the research worker has difficulty in choosing and following the most advantageous line of investigation.

The committee, in making their plans for the establishment and development of the institute, fortunately gave full consideration to the nature of the work to be done, and of the difficulties in having it done efficiently. They accordingly arranged that the institute should have a staff which would include research workers capable of conducting original research in those branches of science which constitute animal nutrition, and, in addition, workers who could conduct feeding and other experiments on a practical scale.

In planning the scheme of work to be carried out, the committee arranged that the chief lines of investigation would deal with some general fundamental problem of nutrition and that, when possible, laboratory researches and practical experiments would be carried out concurrently as part of the same investigation. In the past two years, the most valuable results have been obtained by organised team work, in which different members of the staff attacked the same general problems from different sides, and afforded mutual assistance to each other in their work.

Experiments in Progress.—A reference to the chief investigations at present in progress will illustrate both the nature of the work and how it is conducted.

The results of some of the earliest experiments carried out at the institute on pigs showed that the mineral content of the food was of much more importance than had been thought. They also seemed to indicate that, in some of the work which had been done in connection with vitamins, the results ascribed to these unknown factors were really due to the mineral matter in the foods which were used as a source of the vitamins. An investigation was, therefore, planned to find out (1) how much of each of the essential minerals is required by the growing pig; (2) the extent to which these are present in the food-stuffs commonly fed to pigs; and (3) the influence of excess or deficiency of different minerals on health and rate of growth.

Metabolism researches were carried out with pigs in cages specially constructed, so that the daily output of urine and fæces could be collected and analysed. The food given was also analysed. It was possible, therefore, by deducting the amount excreted from the amount eaten to determine how much was

retained with the different diets fed. From the results obtained it was possible to estimate what amount of the minerals tested the pig required. At the same time as the physiologist and the biochemist were engaged on this work, feeding experiments were being conducted with groups of pigs on different rations, to some of which minerals were added, the influence on the rate of growth and on health being noted. Animals which showed malnutrition and defective growth were killed, and their bones analysed to determine the percentage of the different minerals present. The bones and the tissues were also examined by the pathologist to find out the nature of the disease produced by the various mineral deficiencies. As part of the investigation, experiments were also conducted to show the effects of vitamins on the health and rate of growth of pigs.

Some of these experiments have been completed, and the results published in *The Scottish Journal of Agriculture*, and in other scientific journals, and a summary of them is given in the report of work recently issued by the institute. They need not, therefore, be referred to here.

This work on mineral metabolism and vitamins is being continued and extended. Metabolic researches are being carried out on pigs and cows, and feeding experiments on pigs, cows, sheep and poultry. In connection with the poultry experiments, the institute is participating in a joint investigation with all the colleges of agriculture in Scotland. Some of the work which can best be done under laboratory conditions is being done at the institute, while practical feeding experiments are being carried out by the experts in poultry at the college farms.

Some work is being done on the subject of rickets, a disease affecting chiefly the bones. A joint investigation with the Physiology Department, Glasgow University, is to be carried out in the spring to find out what effect deficiency of calcium and phosphorus has on the bones of lambs, kids and calves.

Another investigation in progress has as its object the determination of the influence of external temperature on the amount of food required by farm animals. The physiologist is conducting researches from which, by collecting and analysing the expired air of goats, he is able to calculate the amount of oxygen consumed, and of carbon dioxide and methane produced by the animals at different temperatures of the environment. From the results of these tests he is able to estimate the energy value of the food consumed. It is proposed to supplement these laboratory researches by feeding experiments with different groups of animals housed under different conditions, so that the gains in weight for the food eaten can be determined at the different temperatures of the houses and under the different conditions of exposure to, or shelter from, the rain and wind.

Reference may be made to another investigation which is of interest because it is being carried out jointly with the Plant Breeding Station at Edinburgh and the three colleges of agriculture.

There has been difficulty in estimating the nutritive value of different varieties of swedes and turnips. At all the colleges and at the institute, series of analyses are being made to determine the average percentage composition of the different varieties of swedes and turnips, and at the institute, metabolic experiments are being conducted to determine their percentage digestibility. Feeding tests with bullocks are also being carried out to find out the relative nutritive value of two of the common varieties.

During the past year, at three different farms, experiments were carried out which duplicated those being done at the institute. These, and indeed all the experiments carried out as joint investigations at other centres are valuable controls. As the research worker is sometimes so keen that his imagination is apt to bias his judgment, duplicate experiments carried out at other centres with observations made by some one who has either no ideas on the subject or a different opinion are often an invaluable control.

It will be seen from this short acccount of the work being carried out that, to some extent at least, the institute is carrying out the intention of the committee by combining in the investigations, scientific researches and practical feeding experiments.

Description of the Institute.—It may be of interest to give a brief description of the institute buildings and lands. They are situated to the north-west of, and about five miles from, the centre of the city of Aberdeen. The terminus of the suburban tramway system and the station of Bankhead on the suburban railway are both about half-a-mile from the main institute buildings. Hence, although the institute is situated in the country, it is within easy reach of both the university and the college of agriculture which is important since the assistance of the staff of both of these institutions is often obtained in connection with the work. It is also conveniently situated with regard to the experimental farm on the estate of Craibstone which belongs to the college of agriculture. The fields belonging to the institute adjoin those of the college experimental farm so that co-operation with the college can be easily arranged.

The institute, which contains what may be termed the scientific departments and offices, is situated about the centre of the land which belongs to it. Separated from the institute by about thirty yards are the experimental farm buildings, which are specially designed for the purpose of carrying out feeding experiments. This arrangement, whereby the laboratories are situated on the farm, is necessary to get the full benefit of team work. The research workers are always available to give advice on technical matters in arranging the feeding experiments. They see the practical application of their results and can direct their work accordingly. At any time it is possible, on short notice, to have a conference of the experts and mass all the available knowledge and experience on any of the numerous subsidiary problems that may arise.

The institute has two floors and a basement. In the basement are the stores, incubating chamber, dark room and heating apparatus. The ground floor is devoted chiefly to the biochemical department and metabolic room where animals can be kept in cages. On the first floor are the physiology department and the combined bacteriology and pathology department. The administrative department consists of a public office and a farm office on the ground floor, and, on the first floor, two rooms for statistical work, and rooms for the secretary and the director. The library occupies the east wing of the first floor.

Both floors are divided longitudinally by corridors which run east and west. The building faces due south. The main laboratories, in which a constant light is desirable, are on the north side of the corridors and the entrance hall, offices, cloakrooms and other subsidiary rooms are on the south side. The building has a flat roof and is so constructed that, if necessary, another storey can be added without interfering with the experimental work going on at the time.

The experimental farm buildings are divided longitudinally by a nine-feet passage lighted from the roof. On one side are food preparation rooms for preparing and weighing out the rations and adjoining these are the food stores. On the other side, the animal houses run at right angles to the central passage with which they communicate. They consist of a piggery with ten pens, each with an outside run, a byre with standings for fourteen cows, a house with six feeding boxes, each with an outside run, and a house with six pens which can be used for any kind of farm animal. In the part of those buildings adjoining the institute are two metabolic rooms for the accommodation of animals kept in cages—the larger one for farm animals and the smaller one for small animals such as guinea-pigs and fowls.

Gas and electricity are obtained from the Corporation of Aberdeen and there is an excellent gravitation water supply from a reservoir in the neighbouring hills.

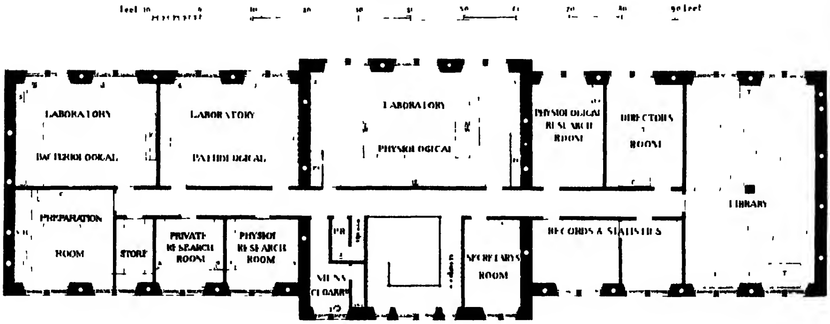
The buildings have been erected on strictly utilitarian lines. There is a minimum of architectural embellishments and no decorative work inside. All the money spent has been devoted to giving accommodation and facilities for the work of the institute.

The farm on which the buildings are erected extends to forty-one acres. The work is hampered by the need of more land and of houses for the accommodation of the men who attend to the animals in the experimental farm buildings. Two small cottages have been erected, one for a caretaker for the institute and one for an animal attendant, but two other cottages are urgently needed.

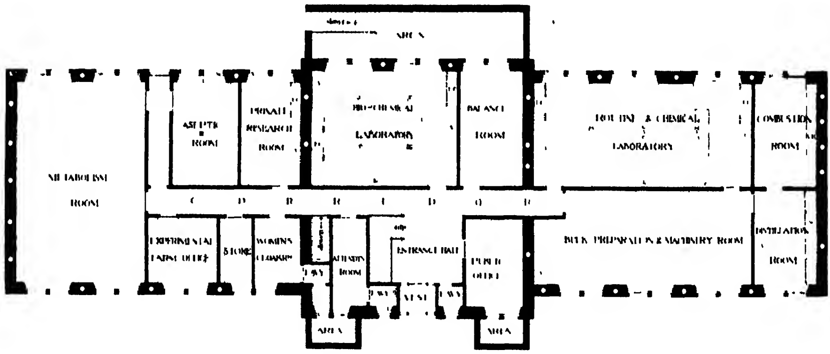
There is also difficulty in connection with shortage of accommodation for animals at times when they are not under experiment. To meet this difficulty, the croft of Essiehill has been leased from the College of Agriculture and a piggery is being erected there for breeding pigs and for fattening off pigs which are of no further use for experimental purposes.

THE ROWETT INSTITUTE

Scale 1/8in 1ft



FIRST FLOOR PLAN



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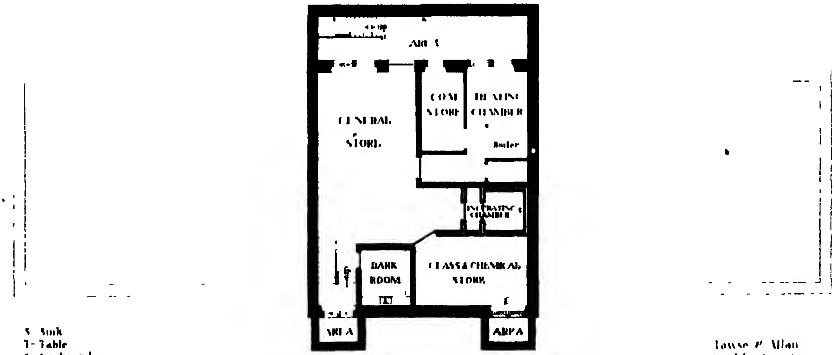
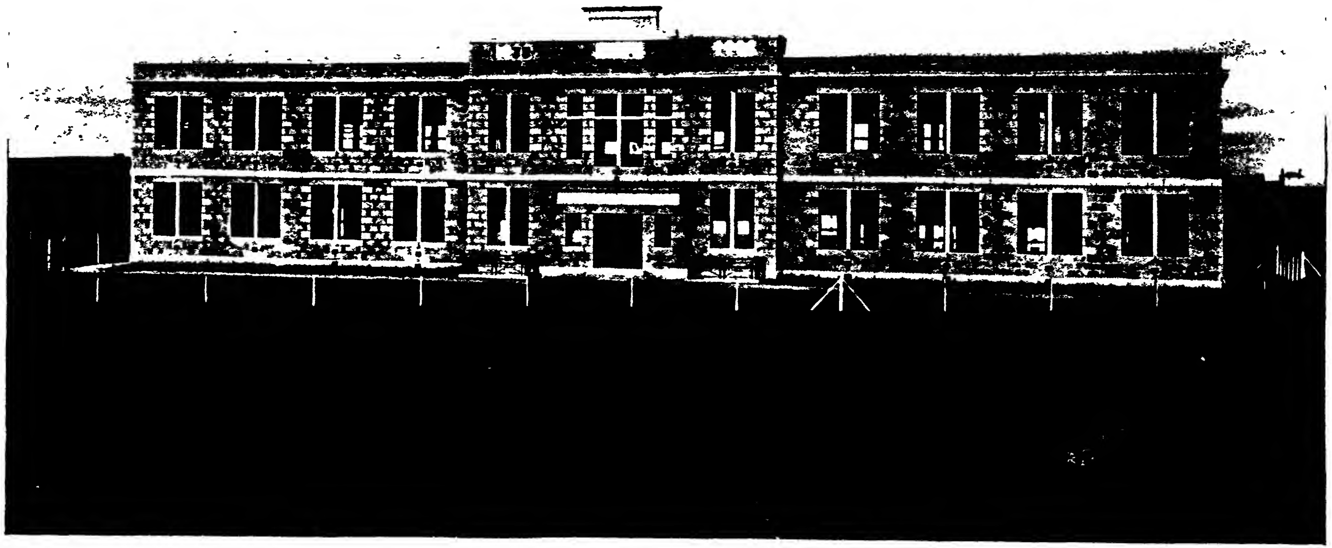


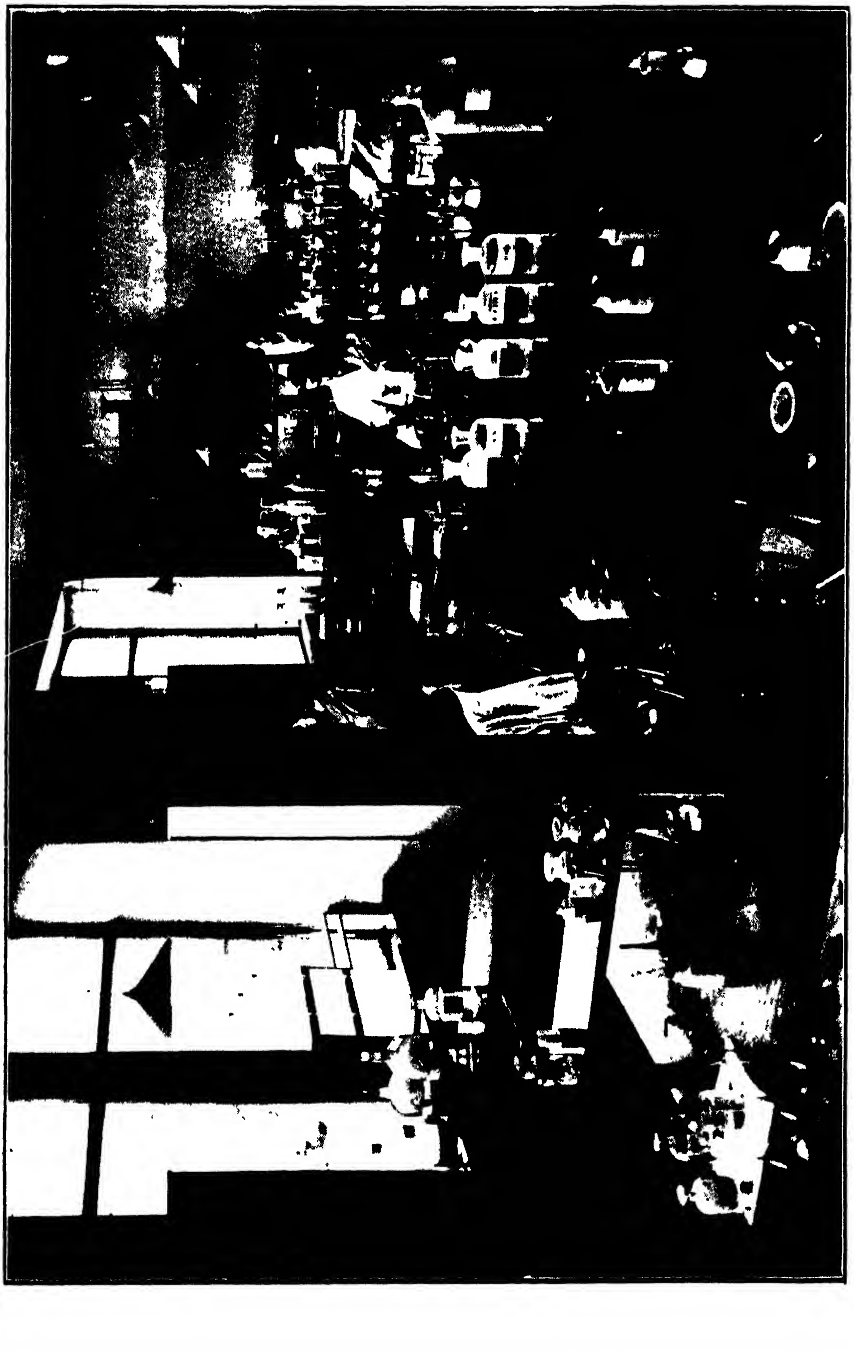
S Sink
T- Table
C Cupboard
FC Fume Chamber
VH Ventilating Hood
PR Photographic Room

BASEMENT PLAN

Lawse & Allan
Civil Engineers
and Architects
Aberdeen

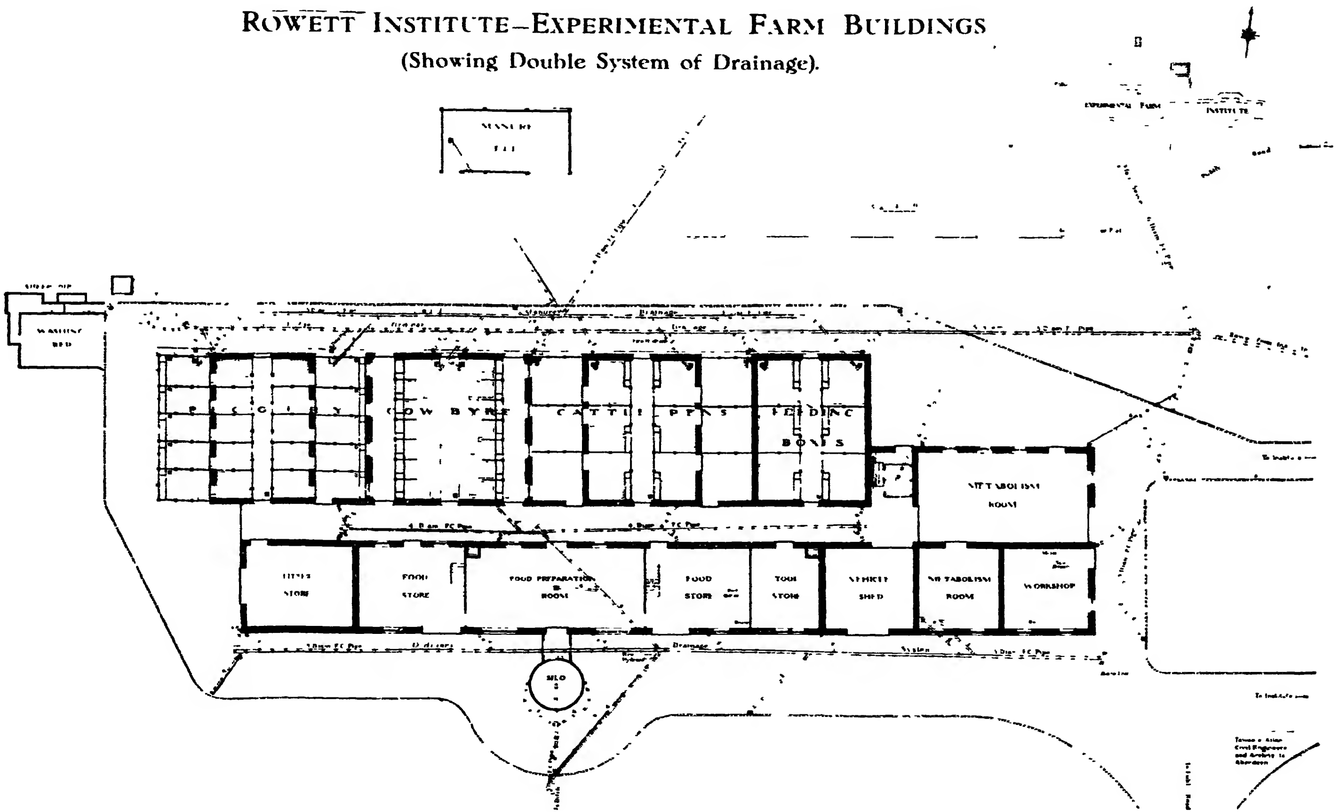


THE ROWETT INSTITUTE.



Rowett Institute—Experimental Farm Buildings

(Showing Double System of Drainage).



National Importance of Research in Animal Nutrition.—Whether or not success attends the activities of the Rowett Institute, there can be no doubt whatever about the national importance of the work on which it is engaged. Animal husbandry, with the occupation that depends directly upon it, is the most important industry in this country. The consumption of foods of animal origin is so enormous that, even though the greater part is produced at home, it is still necessary to import them to the value of over £200,000,000 per annum, and even with that addition there is not sufficient of some of them—milk especially—to meet the needs of the community.

It is a well recognised fact that, for the area under pasture and the amount of other feeding-stuffs used, there is not a reasonable return in animal products. The wastage, which must run to millions of pounds worth of feeding-stuffs per annum, is not to be wondered at when we know so little about the feeding-stuffs used or the processes by which they are converted into foods for human consumption, such as milk, etc. There is probably no other large industry which has been content to do so little towards finding out the nature of the raw materials it uses and the processes whereby these are converted into the finished product.

Nor is the wastage confined to the feeding-stuffs; many methods of feeding, especially the feeding of rations deficient in some essential food constituents, produce conditions of malnutrition that not only prevent the animal from making the best out of the food eaten, but make it more susceptible to the various diseases to which it is liable. The influence of nutrition on the incidence of diseases, even those of an infectious nature, is so great and so fundamental that this aspect of the subject of animal nutrition should receive first consideration in any work connected with the prevention of disease in farm animals.

The Relation of the Farmer to Scientific Research.—It should be clearly stated that it is not the duty of research institutes to give advice to farmers. The farmer knows his own business better than research workers whose knowledge of practical farming, being merely incidental, is certain to be lopsided. What the farmer needs is the solution of problems with which he has neither the training nor the facilities to deal. If he receives information he can judge whether it is of value or not and apply it if he sees fit, according to his special circumstances. The institute exists to try to solve these problems and to give information on specific points, not to give advice on practical farming about which, indeed, the Rowett Institute at least makes no pretence of knowledge.

It is sometimes assumed that the farmer is hostile to agricultural research. There may be a number of small farmers in remote areas who have had such a struggle to make a living that they have not been able to keep themselves informed regarding the progress of agriculture, and who look with suspicion upon any suggestion that does not agree with the precepts of their fathers. The writer's

experience, however, is that the modern farmer is himself the greatest of all experimenters. In his treatment of the land, in the use of manures and seeds and in his feeding of stock, he is frequently trying something new and planning the conditions of the experiments and noting and comparing the results in the same way as the research worker. Even though his advance is hampered by the lack of technical skill and facilities for carrying out the experiments to the stage when he would be dealing with the fundamental problems, he acquires a great fund of information which the writer has found invaluable, both as an inspiration suggesting ideas and as a guide to direct research efforts. So soon as the farmer becomes sufficiently interested to understand the nature of the investigations being carried out, he is not only sympathetic but is willing to assist by putting his knowledge and experience at the disposal of the research worker, and at times offering suggestions for further work. It is quite common for farmers visiting the institute to offer to carry out similar experiments at their farms. In some instances advantage has been taken of these offers.

In conclusion, it should be pointed out that, though the potential value of research work in animal nutrition is so great, the difficulties of obtaining results of practical importance is also great. Groping on the borders of the unknown is an uncertain business and the paths of progress are strewn with failure and disappointment. Results which look so simple and self-evident when obtained often require years of tedious and laborious work to make them look so simple. Even when information has been obtained, it requires to be tested on a practical scale in order to determine its economic value. Indeed, it usually happens that the full fruits of research work are reaped a generation later than that in which the work was done.

THE BIOLOGIST ON THE FARM.—No. IX.

PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

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A Peculiarity of Bats.—The bats are hibernating in a snug corner of the barn or inside a hollow tree or in a hole in the wall of the church tower. Most of them have hung themselves up by their toes and wrapped themselves up in their arms. They do not pass so far into the strange state of hibernation as hedgehogs do, but they are true "winter-sleepers," especially in the North. Mild weather breaks the spell, "re-awakens" them as we say, though we know that hibernation is quite different from sleep. If they recover prematurely from their winter relapse into cold-bloodedness

and fly about at Christmas time, it is in most cases very unprofitable, for there are very few insects for them to eat. But what we started with thinking of was the strange fact that full-grown bats usually pair in late autumn. The spermatozoa which pass from the male into the female duct remain quiescent through the winter, and do not fertilise the ova—or the ovum, for bats are usually uniparous—until the spring ovulation. Insemination is in autumn; ovulation and fertilisation are in spring; and then follows pregnancy. The peculiar feature is the persistent vitality of the spermatozoa throughout the winter months. Perhaps the subject requires re-investigation.

Vitality of Sperms.—What is illustrated in the bats is not unique. In many animals the sperms pass into a special reservoir, a spermotheca, not into the female duct. Thus in two coupling earth-worms the sperms pass from one to the other into two pairs of spermotheca. So it is in the snail, another hermaphrodite, the sperms are stored for a while in a special receptacle and used when the ova are ready to be laid. Then internal fertilisation occurs. Or again, the spermatozoa received by a queen bee during her nuptial flight are kept for a considerable time—it may be a year or even three years—and are used by the queen when she lays eggs in worker-cells and queen-cells. When she lays an egg in a drone-cell, it is not fertilised from the store, and it develops into a drone. Thus a drone has a mother, but no father. Yet it has a grandfather! One of Sir John Lubbock's ants laid fertile eggs, he records, thirteen years after the last sexual union with a male! But this is almost proving too much.

Spermatozoa are very minute cells, a hundred of them could move in a drop of fluid suspended from the head of a pin. They have no stored reserves, but they seem able to survive prolonged quiescence. They are intensely active elements when they get agoing, but their energy can remain for a long time in a potential state.

Hensen states that a hen will lay *fertile* eggs eighteen days after the removal of the cock, and recent observations by Oscar Riddle and Ellinor H. Behre (*American Journal of Physiology*, 1921, 57, 228–249) show that the spermatozoa of ring-doves may retain their fertilising power within the female for nearly eight days. In other words about eight days may elapse between the isolation of the male and the laying of the *fertile* egg. It is interesting to note that the "staleness" of the spermatozoa did not in this case have any weakening effect on the offspring. Nor did it appreciably affect the sex ratio. It would be interesting to discover how long sperms would retain their vitality and fertilising capacity in isolation from both the male and the female, *e.g.*, in a glass tube in some appropriate solution and at a suitable temperature.

Crossing Polecats and Ferrets.—There are plenty of polecats in Europe, but very few in Britain. They linger in the north and west of Scotland, few and far between, for times have changed since, as Dr James Ritchie tells us, 600 skins were on sale at the

Dumfries Annual Fur Fair (1831). In the south they are practically confined to central Wales, and Miss Frances Pitt warns the enthusiastic, that "any specimens found outside that area should be viewed with the gravest suspicion, generally proving to be merely escaped ferrets of a dark colour." A fine animal has been persecuted to the verge of extinction in Britain.

Let us recall a few of its features. It has two coats, a thick drab or yellowish wool next the skin, and longer coarse shining black hairs which throw off the rain. It has a strong skull, broad behind, and the head seen from above is not far from an equilateral triangle. "The muzzle, tips of the ears, and a small patch of fur over each eye, are greyish white, and the last-named patches sometimes join to form a pale band across the face." The length of the head and body is about two inches more in the male than in the female. A common total length for a male, including seven inches of tail, is two feet. Like a cat it looks bigger when it is angry. It also hisses like a cat, but of course it does not belong to the cat tribe of carnivores and has nothing to do with the true wild cat, another rarity in Britain. The polecat belongs to the bear tribe of carnivores, and its near relatives are stoat, weasel and pine-marten. A not very distant relative is the badger which has more suggestion of the bear than the others show superficially. The polecat is a very alert, high-strung creature, nervous, though anything but timid, and it is given to killing much more than it needs. When it is molested it ejects a malodorous fluid from its anal glands and in this respect comes a good second to the skunk.

It is usually believed that the ferret is a domesticated variety of the polecat (*Mustelus putorius*), but one of the leading authorities on mammals, Mr G. S. Miller, is inclined to think that it is more nearly related to *Mustelus eversmanni*, an Asiatic species. Most ferrets are albinos, that is to say without pigment. The fur is cream-coloured and the eyes are pink, the red blood shining through the unpigmented iris. But there are also dark ferrets, often called "fitchets," which have a close superficial resemblance to polecats. In a recent study, Miss Frances Pitt sums up the difference between polecats and ferrets, and they seem to be against the view that the latter is the domesticated variety of the former. There are differences in the skull and in the fur. The ferret is a hardier and more placid animal.

"In such intangible peculiarities as temperament and disposition the ferret is very different from the polecat, as is shown by the ease with which it is tamed even after being neglected while young. An adult-caught polecat is quite untameable, and even half-bred ones require constant handling from their earliest youth to make them docile. It takes a very serious fright to make a placid easy-going ferret emit the vile defensive odour, but the hybrids never hesitate to make use of it. In disease-resistance too the ferret differs from the polecat, being less susceptible than the wild animal to some of the diseases met with in captivity." (Miss

Frances Pitt in *Journal of Genetics*, September 1921, pp. 99–115, 2 pls., 1 fig.).

The ferret crosses readily with the polecat, and the hybrids are fertile among themselves or with either parent. Miss Pitt was able to make a number of interesting observations on the crosses, and it is evidently a matter that should be pursued further. The crosses (first filial generation) show complete, or very nearly complete, dominance of the polecat type as regards outward appearance, but in skull characters the ferret seemed dominant. When the crosses were bred back to the ferret there was in the offspring a weakening and then a disappearance of the polecat coloration and temperament. When bred back to the polecat animals that were apparently pure polecats resulted. "An interesting result of the back crosses with ferrets (albinos) was the gradual weakening of the colour in the pigmented offspring, due not to a dilution of the pigment in the hair, but to a reduction in the amount of dark fur."

In Cardiganshire there has recently been an appearance of "red" polecats. This variety, technically called "erythristic," occurs also in ferrets and is probably due to the loss of one of the "factors" for the normal coloration. Redness is dominant to whiteness (all the offspring of the first generation being red); it is recessive to black-brown (all of the offspring of the first generation being black-brown). In both ferrets and polecats the redness is associated with increased size, and in the ferret at least it is usually accompanied by a quick temper and general increase of vitality. It is very interesting to find it cropping up in natural conditions in Wales and maintaining its foot-hold.

Hibernating Gland.—In various insectivorous mammals, like the hedgehog, in many bats, and in some rodents, like the marmot, there is a so-called "hibernating gland" which remains more or less of a riddle. It is usually situated in the region of the neck, breast and armpit, and has sometimes the appearance of a spreading mass of brownish fat. But it is something more than fatty tissue, though its cells always include many fat globules. Its structure has been recently re-investigated by A. T. Rasmussen (*Proceedings American Association of Anatomists*, in the *Anatomical Record*, 1921, **21**, 78–79), but without very positive result. During the marmot's hibernation the gland supplies only about one-thirtieth of the material consumed, so it is not an important food-reserve. It is rich in blood-vessels but it does not make blood. Its cells are crowded with small granules in addition to the fat-globules. There does not seem to be convincing evidence that it is a gland at all, but what is it?

Vitamins in Seaweeds.—There are localities on our coast where immense quantities of green seaweeds, like sea-lettuce, are available. It would be interesting to feed these to pigs, for Dr Hjort has recently found (*Proceedings Royal Society of London*, Series B, 1922, vol. 93, pp. 440–9, 13 figs.) that oils extracted from green algæ have a very strong effect on the growth of rats fed on

a diet deficient in fat-soluble vitamins. It is improbable that this holds true of green seaweeds only. Marine animals probably get their vitamins from seaweeds; it would be interesting, we say, to inquire whether land animals might not do the same. Perhaps, "on a higher turn of the spiral," we may hear again in the streets the long-drawn-out cry of the seaweed sellers: "Wha'll buy our dulse and tang, dulse and tang." Dr Hjort found that cod roe produced an immediate and rapid increase in the weight of rats; it appears to be rich in growth-promoting vitamins; and drying does not destroy their beneficial influence.

Crowing Hens.—Not very rarely we hear of crowing hens and of hens with an approach to cock-like plumage and comb. In such cases there is usually a partial or total degeneration of the ovary. This involves an activation of the masculine characters which are normally kept latent by the inhibiting hormone or chemical messenger distributed from the "internal-secretion" tissue of the ovary. When the ovary is removed from a duck, it often happens that the putting on of the drake's plumage is practically perfect. What is effected artificially by castration may come about pathologically by an ovarian tumour.

The results just referred to must be distinguished from what Riddle has found in pigeons, that there may be an appearance of very masculine females. The ovary may be quite healthy and yet there is an assertion of the normally latent masculinity. In other words, there are in pigeons (as in some other animals) various grades of intersex constitutions. A curious recent experiment by B. Horning and H. B. Torrey (*Anatomical Record*, 1922, 23, p. 132) resulted in the production of hen-feathering in male fowls (Rhode Island Reds). This was brought about by giving them from the age of three weeks a daily and increasing thyroid dose.

Yellowness in Hens.—The story of yellowness in hens seems to be rather an old story, but it was new to us till the other day and in any case it is part of the biology of the farm. There are some fowls like English Orpingtons which show no yellowness about the legs, beak or body fat; while there are others like Leghorns, Plymouth Rocks and Wyandottes which are yellow in various parts. The yellowness on the body is due to the pigment which makes the yolk yellow; and some chemists have identified it with the yellow xanthophyll which occurs along with chlorophyll in leaves. When the hen has been laying hard there is a migration of the fat-soluble yellow pigment from the body to the yolk, and there is a paling of the little ear-lobes, the vent, the beak and finally the legs. Thus, as A. F. Blakeslee and J. Arthur Harris have shown in detail, a hen which has very pale ear-lobes in October is a hen that has been doing its duty. It may be marked as a high producer. There is a correlation between the percentage of yellow in the ear-lobes in October and the annual egg production. Other characters besides paling which indicate good laying ability are bright colour and full size of comb and lateness of moulting.

FARM PESTS.[1]

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Mammal Pests—continued.

So far, in discussing the mammals destructive to green crops and pasture, we have confined attention to a series of the larger creatures, which affect the crop directly. It is no odd coincidence that these direct destroyers should be the larger herbivores, for the damage they do consists largely of the food they actually devour, and this is proportioned to their bulk of body as well as to their numbers. These are direct rivals of domestic stock for the food supply of the land.

But there is a series of smaller mammals, which, although the direct damage they do may not, in normal times, be of much importance, yet affect very considerably the produce of the land. This, as the following notes will show, may be due to various causes, of which the most general is an interference with the soil on which the crop grows. These indirect destroyers of crops and pasture include the mole, and the field voles and field mice.

The Mole.—The common mole (*Talpa europæa*), the only representative of its kind in Britain, is easily recognised by its

FIG. I.—MOLE. The most general of the indirect pests of farm land. (From Bell's *British Quadrupeds*).[2]

almost cylindrical body, covered with fine soft blackish fur which lies in any direction, its well-hidden eyes and absence of external ears, and its broad, spade-like, outwardly turned fore-feet, all adaptations to its curious underground existence.

In Scotland it is widely distributed. In the cultivated districts

[1] Earlier articles of this series appeared in this *Journal* for July and October 1922.

[2] Figures 1 to 4 and 10 to 13 are due to the courtesy of Messrs Gurney & Jackson, Publishers, Edinburgh and London.

of the north-eastern, central and southern areas, it is particularly common, and even in the northern parts, where a hundred years ago it was rare or unknown, it is becoming increasingly wide-spread. The number of moles present in rich agricultural land was strikingly illustrated in the summer of 1918, when, at Aberlady station, in Haddingtonshire, some 750 dead bodies could be seen suspended along a fence—a few weeks work of one mole-catcher on several farms in the neighbourhood.

The peculiar habits of the mole, its underground life, its continuous activity in the dark tunnels and complicated fortresses which disfigure many a seed-bed and field, its savage ferocity and insatiable appetite in feeding are well known; but a short description of the mole-heaps and runs, which bulk largely in its agricultural significance, will not be out of place here.

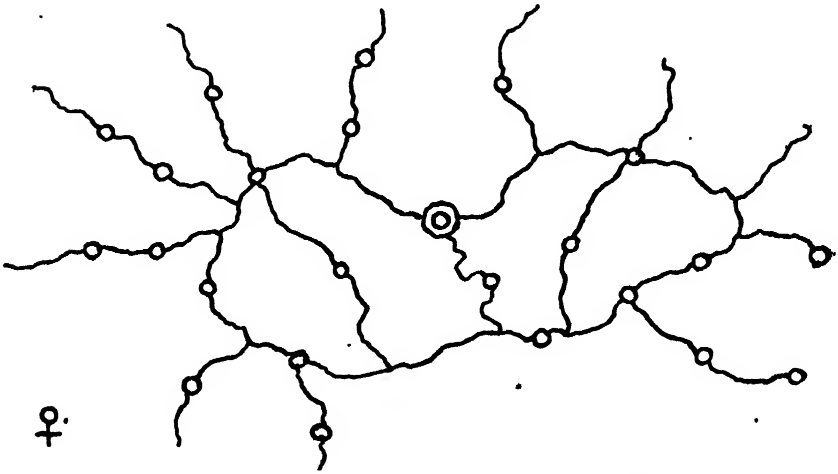

FIG 2.—PLAN OF WORKINGS OF A MOLE. The unbroken lines indicate runs, the single circles mole-heaps or outlets for earth, the double circle is the central fortress. (From Barrett-Hamilton's *History of British Mammals*, after Adams).

The mole's activities centre about a main underground dwelling or fortress, from which radiates, with no regular arrangement, a series of tunnels driven in the first instance in search of food and forming thereafter a set of more or less permanent run ways. These runs may lie just under the surface of the soil, so that their course is easily traced, but such are formed only when the soil is soft after summer rains, or in the moist spring and autumn months; and their formation causes no mole-heaps, for the roof of the run is simply pushed out on the surface. But there are also deeper runs, constructed mostly in dry weather when worms have retired from the surface, and from these the excavated soil can be removed only by being pushed bodily upwards to the surface at definite points. Such points mark the position of ordinary mole-heaps, which are simply formed of the material removed in working the lower tunnels. It is a remarkable fact that though little design is apparent in the direction or arrangement of a mole's runs, there is a definite

distinction between the patterns developed by a male and a female mole. In the case of the latter, as the diagram (Fig. 2) shows, the main runs are quite irregular in direction, connected by branch galleries, and giving off here and there exploration or prospecting galleries, driven out into the neighbouring soil in the search for food. In the case of the male mole the main run is a more or less direct and well-trodden highway, from which the exploration galleries branch and rebranch.

The main underground dwelling or fortress is represented on the surface by a mound larger than the commoner mole-hillocks, and this is due to the greater amount of excavation which has taken place underneath. The essential structure of the interior is arranged about a roundish cavity (*N* in accompanying figures) in which the nest, composed of a ball of dry grass, leaves or moss is

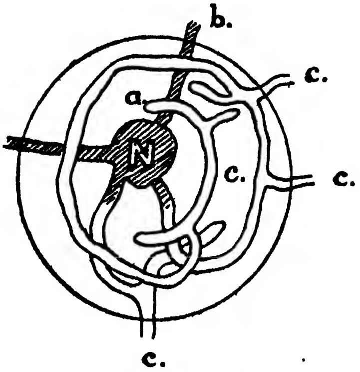

FIG. 3.—Plan of Mole's Fortress, showing nest-cavity (*N*), bolt-runs (*b*), and complicated system of excavation-drifts (*c*).

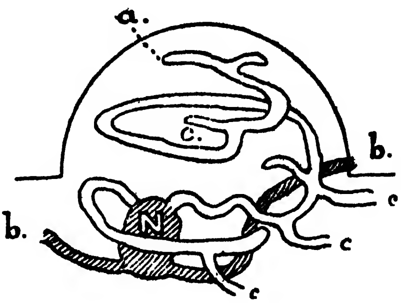

FIG. 4.—Section of same Fortress, showing nest, bolt-runs and spiral excavation-drifts.

(From Barrett-Hamilton's *History of British Mammals*).

placed. From this diverge, in no set order, bolt-runs (*b*) connected either with the exterior or with the general system of underground tunnels, and excavation-drifts (*c*) of irregular form, made for the purpose of ejecting soil excavated from the nest-cavity or bolt-runs.

In a fortress of her own of somewhat similar design the female mole prepares a nest for her young, which as a rule number three or four in a litter, The young are born during a period from about mid-April till mid-June, and are able to leave the nest when about a month old.

Economic Significance.—At various times the kind of food favoured by the mole has given rise to controversy. It has been alleged to gnaw the roots of plants and to devour the insides of bulbs and tubers, but such damage can safely be charged against small rodents, such as field mice, which make use of mole runs. The mole is an insectivore, and true to its order, it almost wholly eschews vegetarian diet. The greater part of its food consists of earth-worms, but it also devours the subterranean larvæ of insects, and has been known on occasion to eat large creatures, such as

frogs, lizards and even birds. All the good that can be said of the mole is that it destroys large numbers of noxious grubs, that its tunnelling allows free aeration of the soil, the easy passage of roots, and helps surface drainage, and that the leaves and grass which it drags underground for nest building add a little humus to the soil.

On the other hand it destroys vast numbers of earth-worms, of greater value than itself in the natural processes of soil fertilization; in tunnelling it breaks and exposes the roots of crops, upsets seed-beds and in the garden displaces bulbs. But these misdemeanours might be overlooked were it not for the surface disturbance caused by runs and especially mole-hills. The general unsightliness caused on lawns and in gardens and parks is the least important part of the damage, for on pasture and on sown land, in badly infested areas, the mounds cover an appreciable proportion of the crop, and in the hay-field and harvest-field they cause obstruction and damage to mowing and reaping machines.

Methods of Destruction.—On these grounds farmers and gardeners reckon the mole an inveterate enemy, and subject it to determined persecution to such an extent that its destruction has given rise to a special class of worker, the professional mole-catcher, whose methods depend upon an intimate knowledge of the movements and habits of the creature. But, without the aid of specialised skill, much may be done to keep undesirable numbers in check.

In other countries attempts have been made to get rid of moles by introducing poison gases, sulphur cartridges and repellant substances into the tunnels, but such attempts have met with little success, and in the end recourse has always to be had to trapping.

Some of the most favoured types of traps, all of which are set in the runways of the mole, are here illustrated. The simplest and cheapest of these consists of a length of steel bent in sugar-tongs shape (Fig. 5). This trap lies along the length of the tunnel, and the two pincer-arms are held apart, when the trap is set, by a piece of iron with a hole in it, in such a way that on the slightest pressure the iron is displaced and the mole is caught by the strong inwards spring of the pincer-arms.

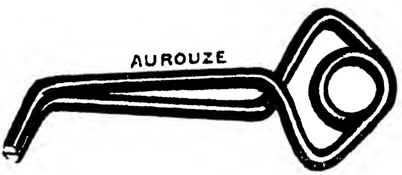

FIG. 5.—The simplest pincer form of mole trap, made of a single length of steel wire. (Aurouze model, Paris).

Various improvements have been made upon this trap, of which two frequently employed in this country are illustrated in Figs. 6, 7 and 8. Here the hinge instead of being at the end lies in the middle, and the trap is placed perpendicularly in the tunnel at such a depth that the perforation in the iron plate which holds the arms apart, lies in the line of the tunnel. The mole in its movement

along the burrow impinges upon the moveable plate, which it throws out of action, allowing the arms to close upon the intruder.

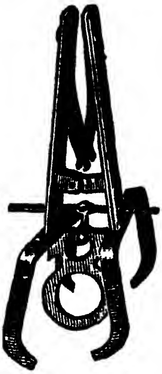

FIG. 6.—More complicated pincer trap, as set in mole tunnel, the arms being held apart by a moveable perforated iron plate. Lane's "1886 model."

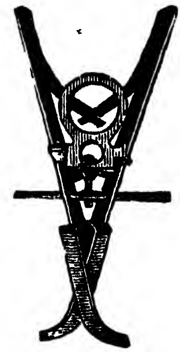

FIG. 7.—The same trap, after being sprung; the perforated iron plate is thrown out of action, on being pressed, and the arms automatically close.

In the south of Scotland, at any rate, professional mole-catchers favour still another type of trap, of which a much reduced illustration is reproduced (Fig. 9). In essence this model consists of a tubular piece of wood representing a short section of a run, into which it is placed. To the barrel is attached a long simple wire spring, from the free end of which is suspended a stout cord, bearing three loops at its free end. The outer loops fit into

FIG. 8.—Another design of the pincer mole trap in set position.

FIG. 9.—SCOTTISH MOLE-CATCHERS' WOODEN TRAP. The trap is set; on the release of the spring by the pressure of a mole against the central peg, the cord is pulled taut, seizing the animal in its loops About ⅓ natural size. (Model by Scott, Edinburgh.)

grooves in the barrel, so encompassing the run; the mid-loop is lightly adjusted on a wooden peg, which projects into the run, and the disturbance of which by a passing mole sets free the spring and jerks the outer loops upwards, enclosing the creature's body.

Other traps have been employed, such as the long wooden tube, fitted at each end with a trap door which permits the entrance but not the egress of moles passing along the tunnel in which it is placed; but on the grounds of unnecessary cruelty

or ineffectiveness they have given way almost entirely to those described and illustrated as on previous pages.

Nothing has been said here of the method employed by some mole-catchers of hunting and killing the mole as it works, by observing the slight movement of the soil (said to be most often seen between 11 a.m. and mid-day) which betrays the subterranean delver; for the method demands an intimate knowledge of the ways of moles, such as the amateur is unlikely easily to attain.

Trapping, to be most effective in reducing the potential numbers of moles, should be most strenuously prosecuted before the breeding season, which commences in mid-April. The traps should be set where the ground is not too dry, for moles prefer moist, rich soil; and the runs chosen should show signs of recent occupation, and should be the more permanent and much-frequented highways, which penetrate ground not frequently disturbed, as along the line of a fence or hedge, or which lead from a poorer to a richer feeding area, as from hard to cultivated land.

The Field Vole or Short-tailed Field Mouse.—The remainder of the lesser and often indirect destroyers of green and corn crops, differ from the mole in being rodents, in which class they belong to the mouse family or Muridæ. Of these the most destructive is undoubtedly the field vole.

FIG. 10.—FIELD VOLE. The main cause of vole plagues. (From Bell's *British Quadrupeds*).

This pest is known throughout Britain under a variety of names, the most familiar being field vole, brown vole, short-tailed field mouse, meadow mouse and grass mouse. These names, indeed, cover two closely related but distinct species, the Highland grass mouse (*Microtus agrestis*), a member of the older British fauna, which has now been driven from England and finds its home in Scotland and particularly in the Highlands; and the common grass mouse (*Microtus hirtus*), which is the common species in England and in the Scottish Lowlands, where its distribution overlaps that of the Highland form.

The appearance and habits of these two species and their varieties are so similar, however, that they may be considered together. Field voles are distinguished by their mouse-like body which, however, differs from that of true mice in its colour, a dull reddish brown or tawny russet, and in its shape, which is more stumpy with a thicker head having a blunter muzzle and very small ears. The tail also is characteristically short, being only about one quarter the length of head and body, which averages four inches.

They are distributed throughout the whole of Scotland and in most of its islands, from the lowland valleys even to the summits of the hills, for Dr W. S. Bruce found them on Ben Nevis at an altitude of 4400 feet. But they prefer areas where grass grows luxuriantly, and so are most common in moist pastures, about grassy hedge-bottoms and in the rough growth on the fringes of woods. There they live in communities, forming an interlacing network of runs on the surface or beneath the surface of the ground. During the breeding season nests of grass are constructed in circular hollows, and in these the young, numbering as a rule about four to eight in a litter, are born. Several litters are produced by a female during the season, which lasts from April till the end of the year, and to this fertility and power of rapid multiplication is due much of the destructive potentiality of field voles.

Economic Significance.—The destructiveness of field voles is due to two distinct factors—the food they devour, and the disturbances they cause in the fields. They are entirely vegetarian in diet and, when it can be found, prefer green stuffs. In late spring and summer they feed largely on the juicy bases of grass or corn stems, so destroying much more growth than they actually devour. In autumn they nibble the ripening grain, and, says Bell, "having followed the labours of the reaper, and taken their share of the harvest, they attack the newly sown fields, burrowing beneath the surface, and robbing the husbandman of his next year's crop ; and at length, retreating to the woods and plantations, commit such devastations on the young trees as would scarcely be credible, were not the evidence too certain to be doubted." Their destructiveness in woodlands, especially noticeable in severe weather when food is scarce, is due partly to their nibbling through the roots of young trees below the surface, and partly to their girdling the bark of both young and older trees just above the surface of the ground.

As for the disturbances caused by voles in the fields, they are of two sorts. In the first place they form, in particular during the barer months of the year, networks of tunnels under the surface of the soil, thus disturbing seed beds and the roots of growing vegetation. And, in the second place, in the more luxuriant months, they form runs amongst the crops and build tough nests of dried grass, which, when they are concentrated in any number, as they often are around the margins of a field, block the blades of the reaping machine at hay cutting and during the corn harvest.

While, in ordinary years, field voles cause damage that must be

reckoned with, in certain abnormal years they increase in such overwhelming numbers as to constitute a vole plague, and in such years the destruction they accomplish is enormous. Many such plagues have occurred in Britain and other countries, but I need mention only the last Scottish experience, investigated by a Departmental Committee set up by the Board of Agriculture, whose Report, published in 1893, lies before me. The plague began with an increase of voles in Selkirkshire in 1888, and the numbers of the pest gradually increased and moved up to the hill pastures of the lowlands, where it reached its climax in 1892. An area of not less than sixty miles in length and twelve to twenty miles in breadth in southern Scotland was overrun, and one witness estimated that in Roxburghshire 30,000 to 40,000 acres had been affected, of which 12,000 to 15,000 acres had been rendered useless, while the infested areas in Dumfriesshire covered 40,000 to 50,000 acres, and in Kirkcudbright 10,000 to 12,000 acres. This infestation was reflected not only in the pasture, but it seriously affected the numbers and condition of the stock.

Methods of Destruction.—If the causes of the increase in numbers, which culminates in a plague, were fully understood plague prevention would be a simpler matter than it is. We have to rely upon expressions of opinion that a succession of dry springs favoured unwonted multiplication (during the plague years litters of nine and ten, in place of the ordinary average of five, were frequent), and that natural restraint had been removed by the previous destruction of "owls, kestrels, hawks, weasels and other vermin." The great safeguard against a recurrence of a vole plague lies in the fact that a plague develops gradually, and that if close watch be kept for the first signs of undue increase, and prompt measures be taken thereupon, there is little likelihood of the attainment of the maximum development which otherwise might be dreaded.

The simplest method of ensuring against undue increase of voles follows upon the realisation of the fact that no enemies are more persistent in destroying them than their natural enemies. They are a staple food supply of many birds and mammals, which, hunting day and night and at all seasons of the year, play havoc in their ranks. While some of these predatory creatures cannot be tolerated in numbers on any sheep farm, such as foxes, ravens, carrion and hooded crows and greater black-backed gulls, there are others which ought to be spared in numbers sufficient to cope with the pest; amongst these may be mentioned stoats and weasels, owls of all kinds, kestrels, buzzards, rooks, common black-headed gulls and perhaps lesser black-backed gulls.

When other than natural agencies seem to be demanded, good results will follow the destruction of rank grass and weeds along field and wood margins, along fences and hedges in cultivated areas, and, in hill pastures, the autumn or winter burning of rank grass and heather. By these means the voles are deprived of shelter,

and suffer from exposure to the weather, as well as to their ever-watchful natural foes.

When the plague stage has been reached, more drastic measures must be adopted. Many of these which have been tried in Scotland and other countries are impracticable, either because of the expense involved or because they are suitable for application only in limited areas, and cannot be used where thousands of acres are overrun. Of these I merely mention the digging of pitfalls, man-hunting with spades or staves, dog-hunting, trapping, the setting free of large numbers of cats, flooding low fields, compressing the earth with rollers or flocks of sheep, the placing of calcium carbide and water in the burrows and the use of poison gases, though in the last case the experience gained in the war may lead to improved materials and methods, and consequently to greater efficiency.

Two methods have been strongly recommended for use on a large scale—the artifical propagation of disease amongst the voles, and poisoning; but neither can be said to be without objection. The first depends upon the inoculation of wild voles by a virulent bacillus, and although varying results have been obtained by this method in Greece (1892), in Russia (1894), in France (1904) and in the United States (1907-1908) it is expensive, and has not been proved to be consistently efficacious.

The second method, of poisoning, is that employed with effect during the Western United States plague of 1907-1908, and recommended by the United States Department of Agriculture as being "the most generally applicable, cheapest and most certain means for controlling mouse plagues at present known." Experiments were made to discover a mode of poisoning at once effective in its action against voles, and at the same time offering the "least possible danger to man, to domestic stock, and to valuable birds and mammals." Phosphorous was ruled out on account of its danger, and the final result of many trials on a large scale was to show that strychnia sulphate was the best poison. Adapting the American methods to Scottish farming, probably the best methods of applying the poison would be either with hay or with crushed oats or wheat. The recipes recommended are:—(1) *Poisoned Hay:* Chop 30 lb. of good, fresh hay into about 2-inch lengths with a feed-cutter. Place this hay in a large metal receptacle, and sprinkle with 3 gallons fresh water. Thoroughly dissolve 1 oz. strychnia sulphate in 2 gallons water by heating in a closed vessel; sprinkle over the damp hay and mix well. (2) *Poisoned Crushed Grain:* Dissolve 1 oz. strychnia sulphate in 2 gallons water by heating. Sprinkle the solution over 60 lb. rolled or crushed oats or wheat in a metal receptacle and mix well. If the preparation is to be kept for several days, two tablespoonfuls of powdered borax may be added to prevent fermentation.

The poisoned hay method resulted in the destruction of 85 to 95 per cent. of the voles at a cost (in 1908) of 35 cents. an acre, and its use was not attended by a single accident to birds or to mammals; the poisoned grain method, while equally effective,

was rather more costly, and had the disadvantage that many birds fell victims to the poisoned grain. The method of application of poisoned hay was that a pinch, say about a teaspoonful, was placed at the mouth of each hole; but where holes were numerous, and fields containing 10,000 to 24,000 holes an acre were treated, a great ultimate saving of labour was accomplished by first dragging the area with a brush drag, so that all holes, old or new, were obliterated. Within twenty-four hours the occupied holes were reopened, and at these poisoned bait was laid. The less precise method of dropping the hay into underground runs was sometimes adopted. It is obvious that at the present time such methods would involve considerable cost in labour; but a desperate disease demands desperate remedies, and if a vole plague is worth arresting the disabilities of the process must be faced.

It is of vital importance in combatting field voles, which are widely distributed, that at whatever stage attempts are made to control their increase, there should be not only co-operation between landlord and tenant, but close co-operation in the work of destruction throughout the whole area of each affected district.

Bank Vole.—From the field voles, which it much resembles in appearance, the bank vole (*Evotomys glareolus*) may be distinguished by the ruddier colour of its coat, and pure white, instead of dusky white, belly and feet, by its rather smaller size, longer ears and somewhat longer tail, which is almost one-half the length of head and body and is thickly haired. Its habits resemble those of field voles, except that it prefers for its burrows dry and sheltered situations in woods or overgrown banks.

Economic Significance.—To gardeners and foresters, more than to farmers in general, the bank vole is an occasional pest; for, although it feeds upon green stuffs, it prefers roots, fleshy fruits, berries and nuts, as well as grain and seeds. It frequently finds its way into gardens, devouring fruits and flowers, and especially bulbs, and it has often been known to gnaw the bark of young trees in plantations in late autumn and winter, and to climb stems and branches in spring to feed on young buds. Fortunately, it never increases to the extent of forming a plague comparable to the field-vole plagues, but there is little doubt that it shares to some extent in the armies of plague years.

Methods of Destruction.—The bank vole is easily trapped, the baits reported to be most effective being a piece of cheese or a split bean, and on a small scale the trapping method is usually employed.

Wood Mouse or Long-Tailed Field Mouse.—As common and widespread in normal years as the field vole, though preferring low, dry plains and warmer valleys to moist uplands, the wood mouse, field mouse or long-tailed field mouse (*Apodemus sylvaticus*), as it is variously called, is readily distinguished from its relative. Its head is finer, its muzzle sharper, its ears larger, more than half the length of the head, and its tail is long, almost as long as the combined length of head and body, about four inches. Indeed, in

general shape, the field mouse more resembles the common house mouse, except that its eyes and ears are larger and more prominent, and its hind legs and hind feet are longer.

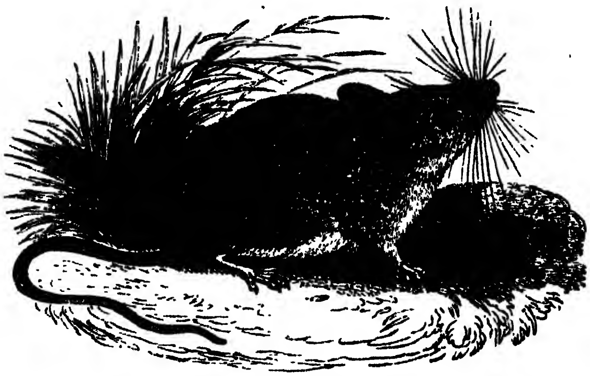

FIG. 11.—WOOD MOUSE OR LONG-TAILED FIELD MOUSE. "One of the most destructive of the minor pests of the corn-field." (From Bell's *British Quadrupeds*).

Like the field vole it lives in burrows, but of a somewhat simpler and deeper type; and in grass-lined nests within these, the young, averaging about five a litter, are born. The breeding period continues over the greater part of the year; and this, together with the fact that litters follow each other at intervals of rather less than four weeks, accounts for the rapid multiplication of the species in suitable years, although widespread plagues comparable to those of field voles are unknown.

Economic Significance.—The wood mouse may feed in part upon leaves and stems of plants, but, like the bank vole, it shows a preference for plant roots, berries, nuts and grain. In summer it may occur in great numbers in corn-fields, where it climbs the stalks of ripening corn to obtain a few grains, scattering the remainder in the process. In the fields, however, a large part of the damage is due to its habit of storing, in special chambers in deep burrows, a supply of food to serve it during the winter months—corn and other seeds, nuts, acorns and such like. "The devastations committed by it," says Bell, "are almost incalculable." In gardens it has an inveterate habit of destroying bulbs of the crocus, hyacinth and lily, and it has been known to rob the hives of bees.

In woodlands it is especially regarded as a pest, for they form congenial dwelling-places, and there in its numbers it not only destroys useful seeds, such as beech mast and acorns, for its winter store, but girdles the bark of young trees and shoots, causing their ultimate death.

Methods of Destruction.—The methods described above for the control of field voles are those most effective against wood or field mice, and here also it is wise to attempt control at an early stage, since methods applicable on a small scale become quite useless when numbers have been greatly augmented over an extended

area. Field mice are a favourite food of most predatory creatures, and the best insurance against their undue multiplication is the protection of their natural enemies, amongst which the most useful are weasels, owls and kestrels.

In gardens, trapping may be resorted to, for the field mouse is easily taken, even in an exposed trap baited with almost any kind of vegetable or animal matter.

Harvest Mouse.—The harvest mouse (*Micromys minutus*) is easily distinguished by its very small size—its head and body being

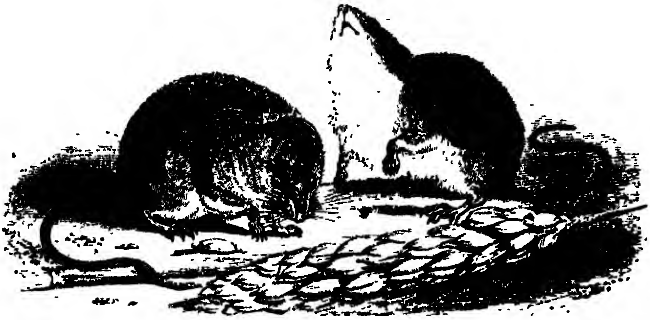

FIG. 12.—HARVEST MICE. The least destructive of native mice. (From Bell's *British Quadrupeds*)

together only 2½ inches long—its reddish back, white belly and long prehensile tail. Widely distributed, though common only in local areas in England, it is almost unknown in Scotland, where its globular nests, attached to the stems of corn or tall grass, have been seldom found. Its breeding season, like that of other mice, is prolonged, and several litters, containing five to nine young, are born in a year.

FIG. 13.—HARVEST MICE AND NEST. The nest is usually built high on stalks of corn crops, its weight and that of its owners being almost negligible. (From Bell's *British Quadrupeds*).

Economic Significance.—The harvest mouse feeds largely upon grains of corn, its light weight (only about one-fifth of an ounce) and prehensile tail enabling it to scale corn stalks with ease. Where it is common, it is often to be found in stack-yards, making its home in stacks of wheat or oats, or even in hay ricks, to all of which it is conveyed fortuitously with the harvested crop. It is only when it is present in unusual numbers that the damage it does can be reckoned as of

any significance in the total destruction caused by mice as a group, and even such damage is largely counterbalanced by the fact that, in the open, harvest mice vary their seed diet by devouring insects, the majority of which, in the corn-field, may be regarded as destructive.

THE FIELD STUDY OF SCOTTISH SOILS.

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In a former article[1] I discussed the origin and field relationships of Scottish soils and subsoils, and showed how these might be classified according to geological origin as: —

1. Boulder clays.
2. Kames—sands and gravels.
3. Glacial lake flats.
4. Dry lake flats.
5. Colluvial soils—rainwash, talus and rockslides.
6. River alluvium.
7. Raised beaches.
8. Carses.
9. Peat.

The largest and most important of these classes is No. 1, which includes a variety of "boulder clays." These vary in texture, colour and composition, according as the rocks from which they have been derived are basalt, granite, sandstone, greywacké, shale, limestone, mica schist, slate, etc. In this article, therefore, we shall describe (1) boulder clay in general; (2) the chief soil-forming rocks and the subsoils and soils to which they give rise; (3) the boulder-clays characteristic of each rock group; (4) the distribution of kames in association with each type of boulder clay; and (5) the classification of Scottish soils in provinces, groups, classes and types in such a manner as may be readily used for soil survey purposes.

Boulder Clay.

The term "boulder clay" is often inaccurate in describing glacial drift: in many cases, as on the Old Red Sandstone, clay is almost absent and pebbles may take the place of boulders. Boulder clays occur in every part of Scotland and at all levels to 2000 feet or more. This form of drift deposit varies greatly in thickness, varying from a few inches to several hundred feet; it is usually deepest in the valleys and thins out towards the higher ground. A typical boulder clay shows no signs of stratification, although it may contain occasional wisps or beds of sand, silt or gravel. The boulders or pebbles are quite distinct in shape and surface from river or sea worn or scree stones; they are facetted, sub-angular and usually striated and may be readily recognised in

[1] See this *Journal*, April 1922, p. 126.

a soil weathered from and resting on boulder clay. Before discussing the various types of boulder clay found in Scotland we shall consider the soil-forming materials present in the chief Scottish rocks.

Soil-forming Materials.—The two most important types of igneous rock which weather to produce considerable areas of soil are basaltic and granitic.

BASALT.—The typical basalt is a crystalline rock, dark green or black in colour. It occurs in the field, in dykes and sills, and may cover large areas, as in Renfrewshire, where it forms plateaux. A common name for this rock is "trap" or "whinstone." Microscopic examination of an average basalt shows it to be made up of a variety of minerals, viz., plagioclase felspars, augite and black iron ore. The felspars are aluminous silicates of soda and lime; the augite is a black or greenish black lustrous mineral of complex composition containing iron, magnesia and lime; the black iron ore (magnetite) is present as abundant small crystals with the composition Fe_3O_4.

The chemical composition of a basalt is shown in the following analysis :—

	Per Cent.	
Silica	45·73	
Alumina	13·48	
Iron Oxides	11·60	
Lime	9·92	36·92
Magnesia	15·40	
Soda, etc.	3·24	

The percentage of silica here is lower than in acid igneous rocks like granite. Lime, iron and magnesia form fully one-third of the rock, the lime being derived from the felspars and augite, iron from augite and magnetite, and magnesia from the augite.

The soil weathered from basalt is a friable, chocolate-brown loam containing fragments of the parent rock usually much decomposed. It varies much in depth and subsoil and may rest directly upon the parent rock, upon a ferruginous orange-brown subsoil, or upon purplish drift formed of basaltic debris.

An average chemical analysis of a number of these soils shows the composition to be mainly :—

	Per Cent.
Silica	37·0
Alumina	13·0
Iron Oxides (Hæmatite and Limonite)	36·0
Lime	0·5
Magnesia	0·6
Soda, etc.	1·5

On comparing this with the analysis of fresh basalt above, it will be noted that lime and magnesia have been largely removed by leaching. This process has not affected the iron oxides which form a remarkably high proportion of the soil, due in part

to the presence in the soil and subsoil of numerous little grains of undecomposed augite and magnetite. These free-working basalt loams are valued for the quality of the root crops grown on them; where they occur above the arable level, as in the Campsie Fells, Kilpatrick Hills and Renfrew-Lanarkshire uplands, the hill grazings are of the highest quality.

GRANITE.—In marked contrast to the dark coloured basic lava rocks is the light grey or red granite which occupies many hundred square miles of Scotland. Most of these granite areas, *e.g.*, in North Arran, Ben Cruachan, Rannoch Moor, The Cairngorms, Caithness and in Galloway, are of interest to the sheep farmer and forester rather than to the arable farmer.

If a specimen of coarse grey granite be examined carefully, it is seen to consist of a closely knit mass of minerals more or less perfectly crystallised. With the naked eye one can distinguish (1) clear glassy blebs of quartz; (2) opaque white crystals of felspar (aluminous silicates of potash and soda); and (3) small, black, flaky, six sided crystals of biotite mica (silicate of alumina with magnesia). A quantitative analysis of a biotite granite shows that these minerals are present in approximately the following proportions:—

		Per Cent.
	Quartz	30
Felspars	Orthoclase	40
	Plagioclase	25
	Biotite Mica	3
	Magnetite	2

These rock-forming minerals, varying in composition, also vary in rate of weathering. The felspars, under the influence of rain-water carrying CO_2 in solution, readily whiten and become soft and break down into kaolin clay (insoluble) and the soluble potassium carbonate. The quartz grains are little altered and wash out of the soft weathered mass as sand. Iron compounds in the biotite and the magnetic oxide of iron become oxidised to the red and orange oxides. So that in a granite soil the constituent parts are white clay and quartz sand stained with oxides of iron. The soluble potassium carbonate is leached out and removed by percolating water. Hence we find a marked difference between the composition of granite and the soil formed from it, as follows:—

	Fresh Granite.	Granite Soil.
Silica	70·91	54·57
Alumina	16·18	25·90
Iron Oxides	1·61	4·69
Lime (CaO)	2·92	0·05
Soda (Na_2O)	1·33	2·87
Potash (K_2O)	5·33	2·16
... ...	...	10·14 Water.

In the soil analysis the higher percentage of alumina is due to

residual clay; the lime content is low because of the solubility of the weathered lime compounds, mostly carbonates.

In the Criffel granite area in Kirkcudbrightshire, the residual granite soil on arable land is rather light and worthless on account of the large proportion of coarse gritty quartz and half-weathered felspar. Most of the granite soils are reddish, and pass down into a heavy red subsoil. Where granite rises to upland and mountain altitudes it is washed bare of soil or carries a covering of peat. In the Loch Etive area the Ben Cruachan granite is covered by numerous gravelly moraines which fill the lower glens.

STRATIFIED ROCKS.—Most of the arable land in Scotland rests upon and is derived from stratified rocks, viz., various kinds of sandstones, conglomerates, grits, shales and limestones.

Sandstones are made up of rounded or angular grains, usually of quartz and felspar. Where the latter is conspicuous the rock is described as felspathic. The percentage of silica in sandstones varies greatly and may be as high as 98. Red or brown sandstones contain a small percentage of iron oxides, and give a red or purplish-brown colour to the overlying soils. In Scottish sandstones, lime, in carbonate form, is usually absent, although it may occur in veins in Silurian grits, as in South Wigtownshire, in the calciferous sandstones cropping out round the coalfields and in the cornstones and greenish-grey bands of the Old Red Sandstones as seen in South Ayrshire, Stirling and Kintyre. In fine-grained sandstones some clay is usually present. The sandstones., as might be expected, give rise to sands, sandy loams and loams ranging in quality from the poor heather-clad quartzose sands of the millstone grit (as at Fannyside, near Falkirk) to the fertile Old Red Sandstone loams of Carrick, Stirling and Perth.

Conglomerates.—Pebbles are often present in the coarser sandstones which shade gradually into conglomerates or cemented gravels, having the appearance of concrete. Perhaps the most notable of these conglomerates are those associated with the Old Red Sandstone, and giving rise to pebbly sands and loams.

Greywacké.—A very large proportion of the soils in the south of Scotland are resting on a great series of hard grey grits (greywackés) with black shales, mudstones and other rocks of Ordovician and Silurian age. The greywacké is composed chiefly of angular grains of quartz cemented together by quartz and clay. This rock is much jointed and breaks readily into small pieces, so that the soil formed from it is usually a stony loam with much quartz-sand and a small proportion of clay and fine silt. Arable land on greywacké, etc., is much broken by rock outcrops—as in Galloway—and the soils vary greatly in depth.

Shales and Marls.—Another important soil-forming rock in Scotland is shale, which is essentially a hardened mud or clay, and may be fissile or compact (mudstone). In colour, shales are commonly grey, red, brown, blue-grey or black, and usually occur in association with sandstones. The shales associated with the

coal-bearing rocks of Scotland contribute very largely to the clays and heavy clay loams of the coalfields, as in Lanark and Ayrshire. When a shale is lime-bearing it is called a marl. This class of rock is much less common in Scotland than in England, and is of limited importance as a soil former. It occurs chiefly in the lower Carboniferous rocks (cement-stones), and in some shales associated with limestones. The term "marl" is also applied by agriculturists to uncompacted calcareous deposits in the beds of lakes or dry lake flats often underlying peat. This "lake marl" is not uncommon, and occurs all over Scotland from Caithness to Galloway and Islay—it usually contains from 50 to 75 per cent. of carbonate of lime, with some siliceous sediment and organic matter, and where easily obtained has proved useful for lime manuring and in reclamation.

Limestones.—There are few extensive outcrops of massive limestones in Scotland, and the part played by the rock as a soil former is a minor one. The writer has examined limestone areas in Lismore Island (Argyll), in Islay and in Kintyre, and has found reddish-brown loams of excellent quality resting on the limestone. These soils are either on drift derived from the limestone, or are residual, and represent the insoluble residue of loam left after the removal of the lime carbonate fraction by rain water in the course of weathering. Such soils are nearly always decalcified, although the subsoil is usually calcareous. The ground water, however, is rich in lime, and the soil seems to get an adequate supply from this source.

SCHISTS.—Among the metamorphic rocks (schists) of Scotland a large proportion of the soil is on peat or moraine gravels, raised beaches or alluvium. Still there are considerable areas where the soils have formed more or less directly from the underlying schists. This is specially true of Kintyre, North Bute, Cowal and North and West Perthshire, where mica schist is the dominant rock, giving rise to a very distinct group of gray-brown to red micaceous loams rich in white mica and silica.

Chief Types of Boulder Clay.—Having reviewed briefly the soil-forming rocks, we may now consider the chief boulder clays formed from the main groups of these rocks. The chief of these are :—

1. Silurian.
2. Old Red Sandstone.
3. Carboniferous.
4. New Red Sandstone.
5. Mica Schists.

For the distribution of these formations, the reader should consult the Geological Map of Scotland, by Sir Archibald Geikie, with descriptive text giving a summary of the geological features of each group of rocks.

SILURIAN.—The greater part of the south of Scotland—south of a line drawn through Girvan and Biggar—is occupied by Silurian rocks. The lower and older group of these is classed by geologists as Ordovician, but, from the soil-geologists point of view all these rocks may be regarded as one group. In the northern

part of this Silurian area the dominant rock is hard greywacké which, in upper Galloway and Leadhills areas, gives rise to lofty uplands and rugged heights frequently rising over 2000 feet. In the southern Silurian zone the rocks are the softer sandstones, flagstones and shales and the land is typically lowland, a large proportion of it being (as in the dairying lands of Wigtownshire) less than 200 feet above sea level. As one passes south across Wigtown, Kirkcudbright or Dumfries, one notes a gradual change from high pastoral to the arable and dairying lands.

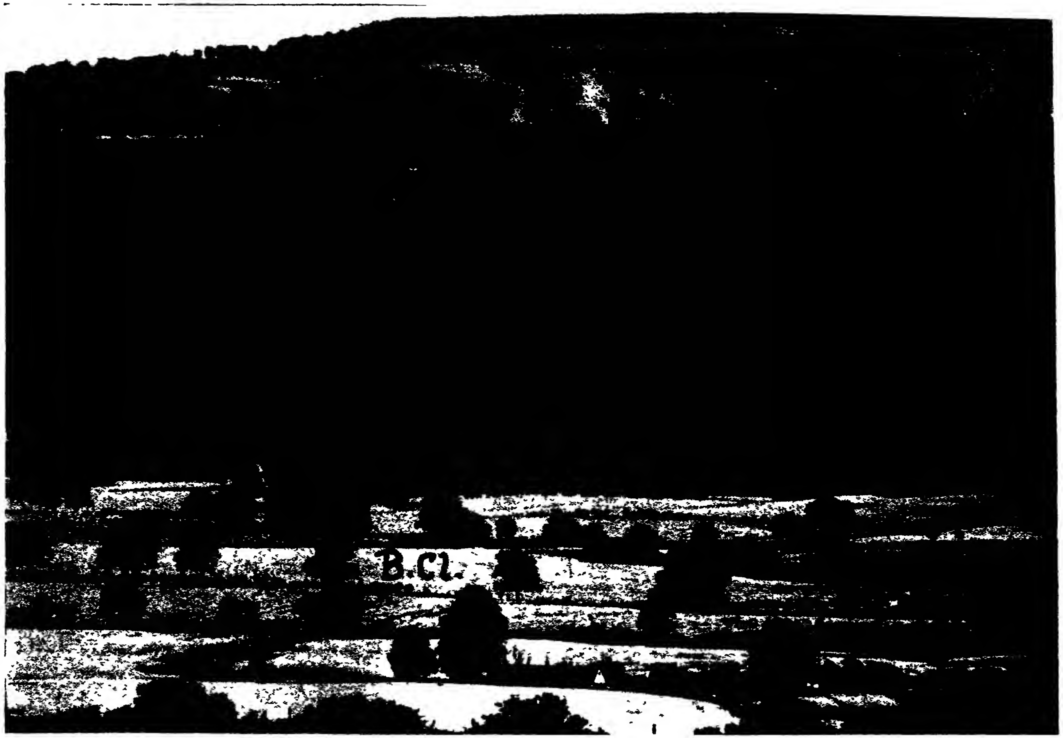
Since the above area has been severely glaciated, a very large proportion of it is occupied by boulder clay which is remarkably uniform in colour and composition over large areas. The usual colour is buff or greyish brown in the north, passing to brown or reddish brown in the south. The Silurian boulder clay is usually hard, stony and compact. It is arranged in drumlins, commonly a few hundred yards long and ranging in height from 20 or 30 feet up to 120 feet. These drumlins are often grouped together in connected mounds with deep lowland peat flats between and around them. The green curved backs of such ridges contrast, especially in Wigtownshire, with the black horizontal lines of the mosses. In between the groups of drumlins are extensive patches of soil which is on very thin till or sedentary on the parent rock. The long axes of the drumlins usually coincide, or nearly so, with the direction of glacial movement in the area.

The soils weathered from the Silurian boulder clay are extremely stony; the pasture lands are often littered with stones about 2 to 3 inches in diameter and in ploughed land, seen after rain, the stones are so conspicuous that the "fine earth" fraction of the soil seems to be quite insignificant. That this impression is wrong, was shown by a quantitative examination; the average proportion of fine earth to pebbles, in ten samples of Silurian loam from Upper Dumfriesshire, being 5½ to 11, *i.e.*, 32 per cent. of fine earth. As a rule, lime is entirely absent from such soils and is present only occasionally in the subsoils as in South Wigtownshire where the underlying rocks are full of calcite-lined fissures.

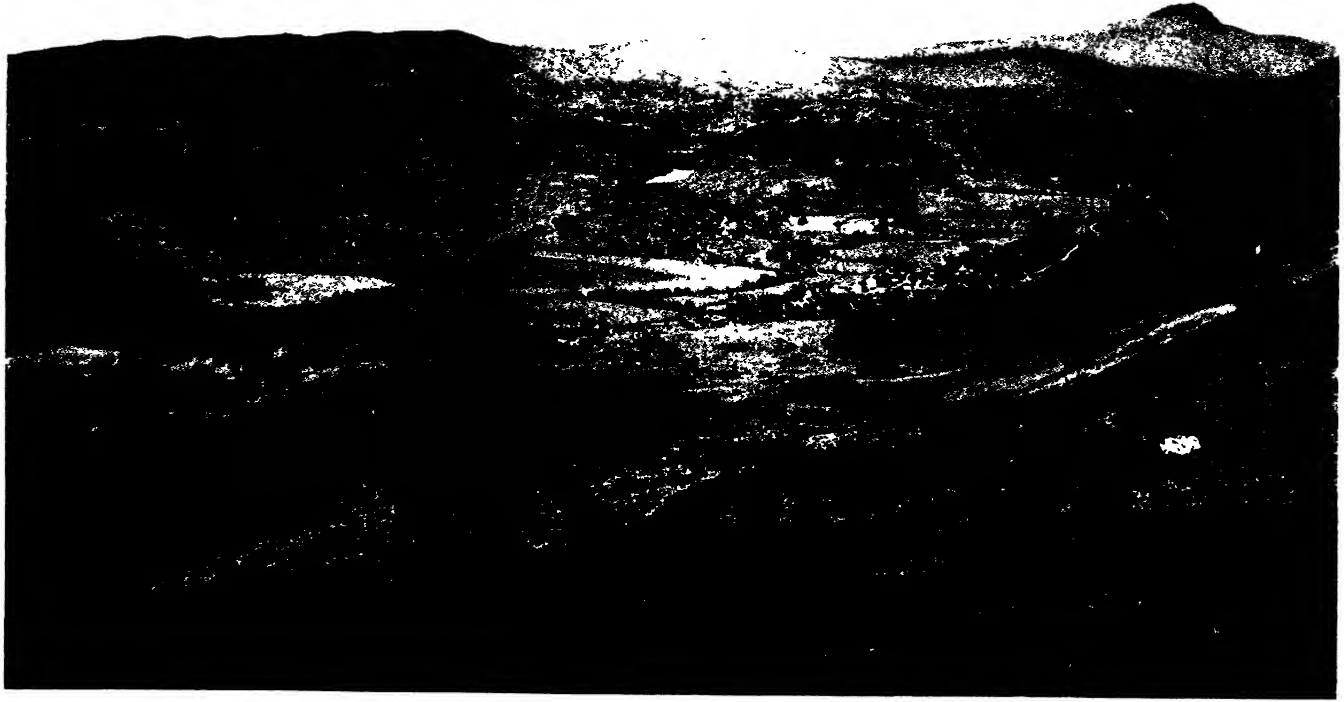
OLD RED SANDSTONE.—The boulder clay formed from the Old Red Sandstone rocks of Central Scotland is—from the soil-forming point of view—remarkably uniform in colour, texture and composition varying chiefly in the proportion and quality of the contained boulders and pebbles. In colour, this important subsoil is purplish red to bright red. It contains a high proportion of felspathic sand, as is found in the parent rock. When wet, the Old Red Sandstone till is pasty or hard and compact, and sets when dry to a hard rock-like mass often forming an impenetrable pavement under the soil. The writer dynamited half an acre of this class of land in South Ayrshire using "farmers' dynamite" in holes 30 inches deep, 1 inch diameter and 3 feet apart, and firing twenty to thirty cartridges at a time by means of a battery. The result was to heave up the surface about 4 inches and to open the subsoil so that a walking stick could easily be thrust into it to a

Telephoto of terraced lavas on north face of Campsie Fells (Stirlingshire):
S = screes.

Weathering of grey granite near summit of Goat Fell in Arran,
showing also the scree slopes of granite blocks and debris.

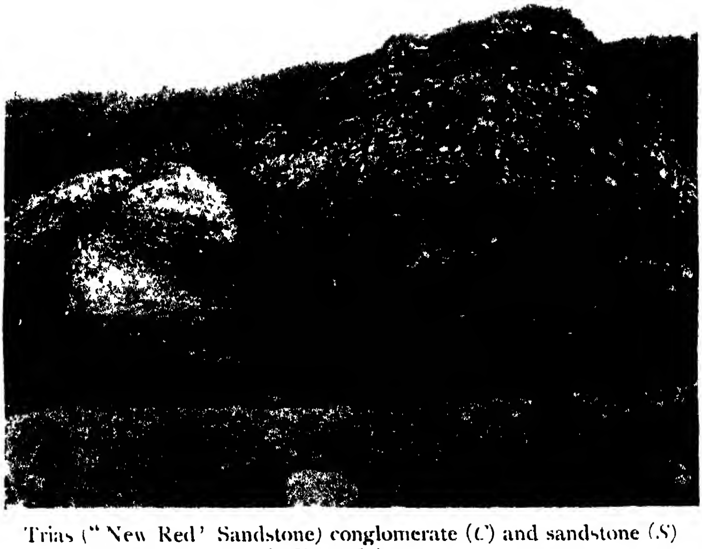


Telephoto across Blane Valley (Stirlingshire) showing Blane Clay (*B.Cl.*) of dry lake flat and (*S*) the red sandy loams on Old Red Sandstone.



Typical landscape on Schists near Aberfoyle (Perthshire) looking westwards from summit of Monteith Hills.

Section near Glenluce (Wigtownshire) showing glaciated outcrops of greywacké and black shale, covered by thin, stony, brown till, capped by a few inches of peat.



Trias ("New Red" Sandstone) conglomerate (C) and sandstone (S) in East of Arran.

depth of 3 feet. It was found, however, that the cost of making the holes, added to that of the explosive was prohibitive.

In thickness the Old Red Sandstone boulder loam is commonly 10 to 15 feet. It is usually disposed in drumlins showing thin soil on top rapidly deepening to the base of the ridge. The soil weathering from this type of boulder clay is the purplish red loam so characteristic of the best potato growing districts in Scotland as for example in South Ayrshire, Dumbarton, parts of Stirling, Perth, Fife and Forfar. The Dunbar red soil takes its *colour* largely from Old Red Sandstone detritus, but contains a large proportion of material from Carboniferous and other rocks.

CARBONIFEROUS.—A third type of boulder clay of great importance in Scotland as a subsoil, is that weathered from Carboniferous rocks. It occurs chiefly in the central plain and forms the basis of much of the dairying land on the Scottish coal-fields. It is an extremely tough, impenetrable, unstratified stony "clay," frequently over 100 feet deep. It varies greatly in colour from place to place; it is commonly grayish blue or purplish brown but may be bright red, dark gray, brown or dark blue. In West Lanarkshire this boulder clay is the chief subsoil and, as is usual with such deposits, gives rise to the remarkable drumlin topography so characteristic of the Glasgow and Mid-Lanark districts on both sides of the river Clyde. Borings in the drumlins show that the Carboniferous boulder clay is usually very thick, depths of 30 to 40 feet being common. The soil characteristic of this tough till is a heavy clay loam, of red or brown colour, which puddles readily when wet and goes cloddy on drying. Next to the carse clays, this clay loam is the heaviest and most intractable soil under cultivation in Scotland.

NEW RED SANDSTONE.—The name New Red Sandstone is used to comprise Permian and Triassic sandstones which are so similar as soil-forming. In isolated areas corresponding closely with the Trias and Permian sandstone basins occurs the New Red Sandstone boulder clay. In many respects this resembles the Old Red Sandstone till, but is more siliceous in composition and brick-red in colour. Taking an average of three analyses of Trias sandstones from Dumfriesshire we find the following chemical composition :—

Silica	93·0
Alumina	2·2
Iron Oxides	1·0
Lime ($CaCO_3$)	1·0
Magnesia	0·2
Alkalies	1·4
Water, etc.	0·7
	100·0

This rock is very rich in quartz sand, hence the high percentage of silica in the analysis. It is, for this reason, inferior to the Old

Red Sandstone as a soil former. The amount of lime is very low and in many varieties of this rock there is no carbonate of lime at all.

The New Red boulder clay is a red sandy deposit often 20 to 30 feet thick. Where it occurs surrounded by Silurian rocks—as in Dumfriesshire—this type of drift is very stony and contains numerous small boulders and pebbles of greywacké and hard slaty shale. On weathering, the New Red drift produces a red sandy loam which in an uncultivated state is often covered by thin moor peat with heather. Even on land which has long been cultivated the soil retains the black or dark brown colour characteristic of sandy moor soils.

The four boulder clays above described, together with the igneous rocks (basaltic and granitic) give rise to the chief soils of the arable parts of central and southern Scotland; they are also present in the Moray Firth area, Caithness, the Orkney Islands, Skye and Mull. The remainder of Scotland, *i.e.*, the Highlands and Hebrides, is composed chiefly of a complex of crystalline schists or gneiss. The schists are predominant in Argyll, Perth, Aberdeen, Inverness, etc.; the gneiss is conspicuous in the Outer Hebrides, Coll, Tiree and the Rhinns of Islay. In these counties the proportion of arable land is small and the study of soils is of service to the forester rather than to the farmer. Much of the lowland on the schistose rocks, especially on the west coast, is occupied by peat, by raised beach sands and gravels of "machars," or by river and lake alluvium; and there is so much ground occupied by rock outcrops and gravelly moraines that the boulder clays, formed from the schists, cover but a small proportion of the whole area.

MICA-SCHIST.—Perhaps the most conspicuous boulder clay in the Southern Highlands is that associated with the mica-schists and well displayed in Argyllshire where it covers a large proportion of Kintyre, North Bute and Cowal. Over these portions of Argyll the drift is patchy, and is deepest in the glens and rock hollows. In colour it is usually grey, brown or buff, but may be strong reddish-brown (Mull of Kintyre) or deep hæmatite-red (North Bute and Colintraive). This till has the usual character of an unstratified compact boulder clay, full of rounded and facetted boulders and pebbles. The relative proportion of stones to clayey matrix varies somewhat, in some cases the deposit becomes gravelly or the matrix is so sandy as to give the till a loamy character.

The characteristic soil on the above boulder clay is a brown micaceous loam or clay loam, resting on a brown or yellowish-brown subsoil. This loam is sticky when wet, because of the large proportion of white mica and chlorite flakes occurring in it in a finely divided condition, approaching the consistency of silt or fine sand. When the soil is shaken up with water in a tube the coarser quartz, felspar and mica grains quickly settle out, leaving in suspension the silt and clay fractions rich in glittering flakes of mica. A small percentage of lime may be present in mica schist, usually less than 1 per cent., but this appears to be present as a

silicate. In all the samples of mica schist boulder clay, examined by the writer, carbonate of lime was absent.

OTHER SCHISTS.—Of the other schists, quartzite is the most siliceous, samples from Islay and Jura showing over 95 per cent. silica. In south-west Jura and part of Islay this siliceous schist is covered by a bright red, sandy or loamy drift with sandstone, probably detritus from denuded outliers of Triassic sandstones, and not weathered from the quartzite. A very large proportion of the quartzite area is occupied by peat or bare rock.

The slaty schists of Islay, Loch Fyne, Appin, Luss and Aberfoyle are usually productive of a stiff gray-blue till, carrying a heavy brown clay loam. The epidiorites and hornblende schists give rise to soils not unlike those from basaltic rocks: in Islay, the epidiorites contain enough free calcium carbonate to effervesce freely with acid. The limestone and calcareous schists, so widely scattered all over the Highlands, in association with schists or with Cambrian rocks (North-West Highlands) usually carry a brown loamy soil resting on till full of limestone fragments or on the parent rock: on sheep grazings, such as the high ground south and east of Ben Lui, the flocks pay great attention to the pastures overlying the great limestone outcrops, and in Islay the soils on the limestones between Bridgend and Port Askaig support some of the best pastures in the island. The Lewisian gneiss has been examined by the writer in the south-west of Islay between Port Charlotte and Portnahaven. This hornblende-orthoclase rock carries a somewhat tough red boulder clay weathering into a red clay loam of great fertility.

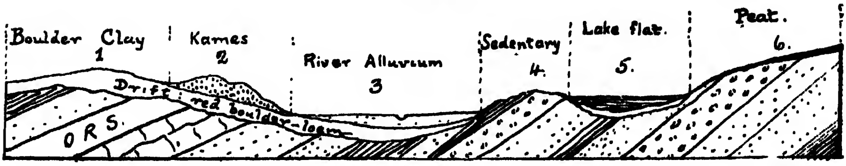
KAMES.—The proportion of kames and moraine heaps of sand and gravel, associated with the dominant boulder clays, varies greatly. By far the largest kame-covered areas are those lying on and largely formed from the Old Red Sandstone and the Trias sandstones. The former are very conspicuous in West Stirlingshire (Drymen and Aberfoyle), East Perth (Gleneagles and Blackford), Forfar, at Lanark and Carstairs: the latter occur over a large tract of Dumfriesshire (Moffat, Lochmaben and Dumfries) and sweeping for some twenty miles from Duncow and Locharbriggs to Annan. Soils of the kame class are of limited extent in the Silurian area, rarely covering more than a few score acres as at Glenluce, Challoch (Newton-Stewart), Isle of Whithorn and adjacent to the Galloway granites. The Carboniferous boulder clay, although it is diversified occasionally by sands and gravels, has few kames as a rule. In the schist area kame soils are of very frequent occurrence in the sides and floors of glens, the kames being sometimes hummocks and sometimes winding ridges. In Islay, Kintyre, Arran and North Bute kames are much less common than in the mainland of Argyll and in Perthshire and further north.

SOIL PROVINCES AND GROUPS.

From the geological point of view, we have seen that soils may be conveniently classified according to (1) agency of

formation—as alluvium, peat, boulder clay, etc.; and (2) kind of soil-forming material—granite, basalt, old red sandstone, etc. The sub-divisions of the former are soil provinces, and those of the latter are groups. Members of a group may be classed according to provinces. Thus in the section shown across the Old Red Sandstone of East Perthshire we have a group of soils formed chiefly from the red felspathic sandstones of the district, and falling into six provinces, viz.—(1) mashed up in boulder clay

SOIL PROVINCES AND GROUPS.



General section across East Perthshire showing arrangement of soils and subsoils in relation to the parent rock (Old Red Sandstone).

or loam; (2) washed out of glaciers as kames; (3) precipitated along the stream courses as river alluvium, or (5) in the hollows of the till as lake alluvium; (6) peat-topped on the moors; (4) sedentary, where drift thins out.

Soil Classes.—The classification of soils by texture involves the sedimentation of the soil minerals in water—a geological and mineralogical study—and a separation of the fractions of sand, silt, clay, etc., which are weighed and percentages calculated. By such measurements, the sandiness, loaminess or clayeyness of a soil may be estimated with more precision than in the field. The importance of laboratory support of this kind to the field man is obvious.

The following classification by texture includes most soils found in Scotland; these may be arranged in the following nine soil classes:—

1. *Kames:*—(*a*) Gravelly soil; (*b*) sandy soil.
2. *Sands:*—Containing over 75 per cent. of sand with much medium and coarse sand. This includes most blown-sands and some alluvial soils.
3. *Sandy Loams:*—Includes many sandstone and alluvial soils.
   (*a*) Medium—containing 50 to 80 per cent. of medium sand.
   (*b*) Fine—50 to 80 per cent. of fine sand.
4. *Loams:*—A somewhat indefinite class including many soils of great general usefulness. These are more retentive than the sandy loams on account of a proportion of the sand being replaced by silt and clay. Loams should contain 30 to 50 per cent. of sand and less than 15 per cent. of clay.
5. *Silt Loams:*—Containing more than 50 per cent. of silt (often 60 to 65 per cent. silt) and less than 20 per cent. of clay. Many fine grained alluvial and carse or slob-land soils fall into this class, as on the lower Kelvin, Clyde, Nith and Forth.

6. *Clay Loams*:—Containing 15 to 25 per cent. of clay, 20 to 50 per cent. of silt, with sand for the remaining fraction. This class of soil is commonest on the Carboniferous boulder clay.
7. *Clays*:—Containing 30 per cent. or more of clay with a large proportion of silt—30 to 40 per cent. The extent of clay land of this kind in Scotland is not great; it occurs chiefly on carses (associated with silt loams) and dry lake flats such as those found among the drumlins of carboniferous drift.
8. *Peaty Soils* comprising:—

(*a*) Peaty Clays = peat and clay loam.	River alluvium and lake-flat meadow land.
(*b*) „ Loams = 15 to 40 per cent. peat and sandy loam.	
(*c*) „ Sands . . .	Raised-beach flats, kames and moorland.
(*d*) „ Gravels . . .	

9. *Peat*:—Containing a varying amount of organic matter (commonly over 40 per cent.), with an admixture of mineral matter, especially blown sand or silt from flood water.

Soil Types.—Natural groups of qualities, such as occur among soils, cannot be precisely described by words and so we have recourse to comparison with types. The soil type is the unit of soil classification and in the mapping of soils, as in the mapping of rocks, is of much practical value. On the geological map of basaltic plateaux, such as the Campsie Fells area, we find various kinds of basalt distinguished by suitable colour or lettering as "Craiglockhart type," "Dalmeny type," etc., each of these types being a unit of rock classification. And so also with soils. The field worker finds an area at A, in Stirlingshire, occupied by a chestnut-brown clay resting on laminated mottled clay; he finds a very similar soil at B in Perthshire and at C in South Ayrshire, and as he observes B and C he reflects "these are extremely like A." A is then given a name—in this case the "Gartness brown clay"; samples of A, B and C are compared in the laboratory and if the three soils are sufficiently similar, the areas B and C are mapped as "Gartness brown clay." The type name is conveniently made up of two portions, one (*e.g.*, Gartness) referring to a town, village or natural feature existing in the region where the soil is well developed or is first identified and the other giving a brief description (*e.g.*, "brown clay") of the colour and texture of the soil.

Soils belonging to the same type may lie on widely different subsoils. This may affect their agricultural value to a considerable extent, *e.g.*, blown sand on tight clay differs from blown sand on gravel or peat and thin peat on grey sand may be greatly inferior to similar peat on blue carse clay. So that it is important to

subdivide soil types into phases or varieties according to subsoil. This should not be carried beyond practical needs and should be done only where the subsoil exercises a marked influence upon soil fertility.

SOME FACTORS AFFECTING THE VALUE OF POTATOES FOR SEED PURPOSES.

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THE opinion is held widely among potato growers that a variety of potato if continually grown under the same soil and climatic conditions will inevitably deteriorate, and that if the yield, quality and disease-resisting powers of the potato crop are to be maintained, it is necessary that new varieties which have been raised from true seed, should be introduced from time to time, or that a change of seed should be frequently made from different soil and climatic conditions, Many different opinions, however, are held regarding the ultimate cause, or causes, of this so-called deterioration, and in the following pages we intend to discuss some of these in the light of the results of experimental work dealing with this particular subject, which has been carried out at Craibstone during the past few years. The experiments are still being continued, but the results so far obtained are sufficient to enable us to come to more or less definite conclusions in connection with this matter.

Shortly stated, the experiments referred to have been carried out for the purpose of obtaining information regarding the effect of—

1. Continuously selecting large, medium or small sets.
2. Continuously selecting seed from large plants and from small plants.
3. Using seed obtained from a good crop and from a poor crop.
4. Age of variety.
5. Time of lifting crop.
6. Disease.

Large, Medium or Small Sets.—It is asserted by many that the ordinary method of selecting tubers for seed purposes is largely responsible for the falling away in the yield. The most common method practised is to put the potato crop in bulk through riddles with different-sized meshes, and to retain the medium-sized tubers for seed purposes. Generally, the tubers used for seed are those that pass through a sieve with a mesh varying from 1⅝ inch to 2 inch, but fail to pass a mesh of about 1¼ inch, or tubers weighing approximately 2 to 3 oz. It is argued that, where this method is practised, the grower is, unconsciously perhaps, but nevertheless certainly, selecting his seed potatoes largely from comparatively weak plants, and that such a system continued for

any length of time is cumulative in its effect, and must eventually lead to a general weakening of the vitality of the variety or strain. It is a well-observed fact that, if a strong plant and a weak plant of the same variety and grown under the same conditions are harvested separately, the strong plant usually bears, relatively, a larger proportion of big tubers than the small, weak plant, and, therefore, when the bulk of the crop is riddled in the manner described, it follows that, of the tubers of medium or small size, more have come from the weak plants than from the strong plants. The constant use, therefore, of sets of medium or small size selected in this way is believed by many to be the main cause of the deterioration in the yield, and it is suggested that the variety may be regenerated by occasionally using large tubers, either planted whole or cut, the argument being that where the large tubers are separated also by the riddling method, the majority of these will come from the stronger-growing plants in the field.

During the past few years we have carried out a number of experiments with a view to determining whether these ideas are correct or not. Three varieties of potatoes, representative of three well-marked types—Abundance, British Queen and Great Scot—were used for the purposes of these experiments. Three sizes of tubers of each variety were selected from the ordinary crop—large, medium and small—the large being cut into two about three days before planting. The large tubers selected were twice the size of the medium, so that the sets planted in each case were of the same size and weight. On the other hand, the small sets selected were half the size of the medium sets. All three were then planted under identically the same conditions, and the same method of separation was practised in subsequent years, that is, every year the large sets were selected from the plants arising from large sets, medium from plants arising from medium sets, and small from plants from small sets. Table I. shows the results of the five years, 1918–1922, inclusive. Regarding these figures, we must

TABLE I.

THE EFFECT OF CONTINUOUSLY USING (*a*) LARGE CUT; (*b*) MEDIUM WHOLE; AND (*c*) SMALL WHOLE SEED.

	1918.		1919.		1920.		1921.		1922.	
	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
1. ABUNDANCE—										
Cut	16	11	17	12	15	2	12	7	20	3
Medium . . .	15	4	14	8	15	2	11	0	20	17
Small . . .	14	3	15	7	14	0	11	11	19	11
2. BRITISH QUEEN—										
Cut	14	14	15	4	14	15	16	6	18	15
Medium . . .	15	1	14	19	14	14	17	16	19	17
Small . . .	13	2	15	4	14	3	16	1	18	4
3. GREAT SCOT—										
Cut	16	5	14	14	15	10	18	10	21	7
Medium . . .	17	17	15	7	14	12	19	2	21	7
Small . . .	13	13	13	10	11	11	16	19	18	2

point out that the medium sets have, in the main, given rather the heaviest crop, and that the lightest crop, on the other hand, has been got from the use of the small sets. Generally, it will be found advantageous to use good-sized seed rather than small, because, with the larger food store in the seed, the plant gets a better start, and the crop is almost invariably heavier. The important point, however, to notice in this table, is that the relative yields from the three classes of sets are practically the same in 1922 as in 1918. If selection in this way has any effect at all, it would naturally, under the conditions here, be cumulative, but there has been no falling away in the yield from the use of the small sets, nor any addition to the yield from the use of the medium or large cut sets. That is, the continued selection of the small sets has not led to any deterioration, neither has the continued selection of the large sets led to any improvement. It was further observed in each year when the crops were harvested, that the proportion of small tubers from the small sets was not any greater than from the large or medium sets. Indeed, it was noticed that from the large cut and from the small sets there was rather a larger proportion of what we might call good show specimens than from the medium sets. In the case of the crop from the small sets, in one or two seasons there was considerable difficulty in getting a sufficient number of small tubers to continue the trial. One point of interest which emerged in these trials, but which has no direct bearing on the subject under discussion, was that the crop from the medium sets not only tended to be the largest, but it also ripened slightly earlier than that from the large cut or small sets.

Seed from Large or Small Plants.—As many, however, still hold the opinion that improvement can be effected in a potato variety by taking sets from specially selected, large, strong-growing plants, and that, conversely, deterioration can be brought about by selecting tubers continuously from small weak-growing plants, a further series of experiments was carried out for the purpose of testing more fully and accurately how far these ideas are justified. In this case, a number of strong-growing plants and a number of small plants were selected from an ordinary field crop of the same variety, Great Scot. Special care was taken to see that all the selected plants were entirely free from disease. Tubers of exactly the same size from each class were then taken and planted separately in drills alongside each other. In the first year it was found that the tubers from the large strong-growing plants gave rise to both large plants and small plants, and that, equally, the tubers from the small plants gave large plants and small plants. The same system of selection was practised in subsequent years. Every year, tubers from the best plants, the progeny of tubers from the best plants being selected on the one hand, and the progeny of the smallest plants from tubers of the smallest plants on the other.

Table II. shows the result of this method of selection carried on from 1918–1922 inclusive. The total weights of the tubers from the selected plants in each case are indicated in the table by

heavy type. Here, it will be noted that the average yield of tubers from the selected large plants at the commencement was 3 lb. 11 oz., and from the small selected plants only 12½ oz. In subsequent years, however, the average yield per plant from both classes was almost identical, and in 1922 was, in the case of the large plant selections 2 lb. 3 oz., and in the case of the small plant selections 2 lb. 2 oz., the difference being almost entirely

TABLE II.

EFFECT OF CONTINUED SELECTION FROM LARGE PLANTS AND SMALL PLANTS.

	Series A.—Large.										Series B.—Small.									
	1918.		1919.		1920.		1921.		1922.		1918.		1919.		1920.		1921.		1922.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
			1	10	1	8	1	10	2	13	0	12	2	11	1	12	1	15	2	11
			1	15	0	11	2	0	2	3			1	9	0	6	2	0	1	15
	2	13	1	4	1	6	2	2	2	1			1	7	1	3	0	11	1	12
			1	5	1	14	1	4	2	14			0	11	1	0	1	5	2	3
			1	2	0	13	1	9	2	7	0	12	1	8	1	6	2	0	2	10
			1	3	1	3	1	5	2	13			1	11	1	8	1	15	2	9
			0	10	2	1	2	10	1	15			0	13	1	12	0	15	2	2
	3	6	1	8	2	0	0	12	2	15	1	0	1	9	2	0	1	15	1	15
			0	15	1	4	1	13	1	1			0	11	0	14	2	9	2	13
			0	15	1	4	2	9	3	5			1	6	2	15	0	15	2	7
			1	7	0	10	1	13	0	12	0	13	1	14	1	14	1	6	1	4
			2	0	1	1	2	15	2	3			1	12	0	13	1	14	1	13
	3	8	1	6	2	9	2	0	2	10			0	10	2	3	1	0	1	14
			1	4	1	4	1	0	1	11			2	3	2	7	2	6	1	11
			1	3	1	6	1	12	1	15	0	12	1	1	1	13	1	6	1	1
			1	2	1	4	2	1	1	8			0	11	2	8	1	12	3	4
	5	2	2	1	1	8							1	3	1	5				
			0	15	1	14					0	10	0	10	1	7				
			1	1	0	9							1	6	1	4				
Total Weight .			24	14	26	5	29	3	35	2	...		25	6	30	7	26	0	34	0
Average .	3	11	1	5	1	6	1	13	2	3	0	12½	1	5½	1	9½	1	10	2	2

Drills 5½ yards long, 27 inches wide.
Distance between sets—1918–20, 10 inches; 1921–22, 12 inches.

negligible, and being more than covered by the ordinary experimental error. A closer examination of the table, too, will show that in Series B, representing the small plant selections, we have quite as large a yield from some of the plants as from those in Series A. Even after five years of continued selection along these lines, the average yield from the large plants has not improved, neither has there been any falling away in the yield from the selection of the small plants. It was noted, also, that there was no difference in the average weight of the tubers from the two series. These figures, therefore, prove conclusively that no improvement has been effected by the continued selection of sets from large plants, and that, so long as the plants are healthy, deterioration need not necessarily follow where sets from small plants are continuously used. These results are quite in keeping

with the ideas generally held at the present time regarding selection inside pure lines. A potato variety or strain that has originated from one single plant is a pure line in the strictest sense of the term, and inside a pure line it has been proved that continued selection can effect no change. The only possibility of improvement or deterioration in the potato, or, indeed, in any plant that is propagated asexually, is where bud variation takes place, but all authorities agree that bud variation is so rare, except perhaps as regards colour, that it need scarcely be taken into consideration at all in this connection. It is true that many claim to have improved a pure strain by single plant or single tuber selection only, and have evidently succeeded in doing so, but in such cases it will probably be found that the weak plants dealt with were weak simply because they were attacked by some such disease as leaf roll or mosaic, or that the crop at the outset was really a mixture, and that the selection was what is known as "rogueing," and, therefore, any improvement effected was merely brought about by the elimination of the inferior varieties.

Seed from Heavy or from Light Crop.—Another series of experiments was carried out to find whether potato sets from a heavy crop would give a better return than sets from a light crop of the same variety, and grown in the same soil. Five varieties of potatoes were planted in a field where part was heavily manured and part left unmanured. In the following spring, tubers of exactly the same size were taken from each lot. These were planted in alternate drills in a plot manured and cultivated in the same way all over so as to eliminate, so far as possible, any differences arising from inequalities in the condition of the soil.

Table III. shows the result of this experiment. Here, it will be noted, the average crop in 1921 from the manured area was 12 tons 5 cwt., and that from the unmanured area 6 tons 6 cwt., a difference of nearly 6 tons per acre. In the following year, however, the yields from the seed from these two crops were practially the same, the average being 17 tons 4 cwt. and 17 tons 9 cwt. We see, therefore, that the treatment given to the crop from which the seed was originally selected had no effect whatever on the productive powers of the seed itself. Grown under the same conditions of soil and manuring, no permanent hereditary change has taken place leading either to improvement or to deterioration.

Age of Variety.—Many authorities hold that a variety or strain will deteriorate simply owing to age. They believe that a certain amount of the energy of the variety is expended in the production of each successive generation, that is, that the work of propagation is using up the inherent energy in the potato, and that, therefore, the vitality of the variety must eventually in this way be very much lowered. So far, however, as our observations have gone, we have seen nothing to support this. Close attention, for example, has been paid to many different varieties which have long been cultivated, and we have seen no signs whatsoever of deteriora-

tion. Further, we know several farmers in our neighbourhood who have grown the same varieties of potatoes for the past thirty or forty years, and they find these varieties growing as vigorously to-day as they did in the year when they were first planted. Many cases

TABLE III.

EFFECT OF PREVIOUS TREATMENT ON YIELD.

	1921.											
	Good Crop.						Poor Crop.					
	Large.		Small.		Total.		Large.		Small.		Total.	
	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
Ajax . . .	13	6	1	7	14	13	5	16	1	14	7	10
Bishop . .	11	13	0	16	12	9	6	10	0	11	7	1
Epicure . .	7	18	1	3	9	1	5	10	0	13	6	3
Majestic . .	13	8	1	1	14	9	4	14	0	12	5	6
Nithsdale . .	9	4	1	9	10	13	4	10	0	19	5	9
Average . .	11	2	1	3	12	5	5	8	0	18	6	6

	1922.											
	Seed from Good Crop.						Seed from Poor Crop.					
	Large.		Small.		Total.		Large.		Small.		Total.	
	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.	Tons.	Cwt.
Ajax . . .	15	12	1	12	17	4	15	16	1	7	17	3
Bishop . .	13	17	2	9	16	6	13	12	3	5	16	17
Epicure . .	16	17	2	9	19	6	16	6	2	3	18	9
Majestic . .	16	17	0	16	17	13	18	10	0	11	19	1
Nithsdale . .	13	12	1	12	15	4	13	6	2	9	15	15
Average . .	15	8	1	16	17	4	15	10	1	19	17	9

might also be cited of plants other than the potato, which have been propagated asexually for many generations, which are to-day quite as strong and vigorous as they were many years ago, and reasoning from analogy, we may conclude that the same holds good of the potato. If age were responsible in itself for deterioration, it would follow that this deterioration would set in with any particular variety at the same time, no matter under what soil and climatic conditions it were grown. Now, it is well known that a variety will continue to grow strongly and vigorously under

certain soil and climatic conditions, but will deteriorate very rapidly under others. In both cases we must note that the potatoes are of the same age, and, therefore, the so-called deterioration, where such appears, must be due, not to age, but merely to the unsuitability of the variety to its environment. If this is so, it should be found that sets from such a deteriorated crop, if planted again under favourable environmental conditions, will regain their vitality. We have not carried out experiments dealing directly with this point, but during the past few years we have collected seed of many varieties from different districts all over Great Britain, and these have been grown at Craibstone alongside home seed. Table IV. gives the returns from the imported seed as compared

TABLE IV.

HOME SEED *v.* IMPORTED SEED.

VARIETY.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.
	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.	T. C.
A. Up-to-date—Craibstone	16 1	14 3	12 12	13 0	19 1	16 8	23 4	19 14
B. Beehive—Haddington .	10 1	6 19	11 0	14 0	13 8	16 16	19 14	16 15
Lord of the Isles—Essex	...	7 8	6 19	10 15	16 0	12 6	17 3	14 17
Victorious—Norfolk .	...	8 12	11 15	13 8	17 1	15 14	18 14	19 14
King John—Essex .	...	6 3	6 10	8 8	11 0	12 2	12 2	11 11
C. Premier—Norfolk . .	8 15	7 17	6 12	8 5	6 6	9 19	10 6	9 13
A.	100	100	100	100	100	100	100	100
B.	...	54·4	78·5	94·2	82·2	91·2	78	86·8
C.	54·5	49·4	51·9	63·8	45·4	67	47·2	53·8

with home seed of varieties of the Up-to-date type. In order to make the comparison clearer, and to get over the difficulty of variations due to season, we have taken the crop of the home Up-to-date for each year as being equal to 100, and represented the others as percentages of this. In the first year or two, although the plants in Series B were not so vigorous, they were quite healthy and free from disease. As will be seen from the table, however, they gave a comparatively poor yield as compared with the return from the home seed. After the third or fourth year, however, there was a great improvement in the vigour and in the yield. In other words, the imported seed had by this time gained, or regained, vitality nearly equal to the home seed. It will also be noted that these varieties came from drier and warmer districts than ours. It is quite apparent, therefore, that the poor returns at first were due simply to some temporary weakening in the vitality of the potatoes owing to the warmer and drier conditions under which they had previously been grown, and in support of this, we have found that potatoes taken from cooler and moister conditions, even in England, have from the outset given quite as good returns as the home-grown seed.

Effect of Diseases.—Several crops from imported varieties of seed, however, have not only been failures from the outset, but are showing no signs of improvement after eight years cultivation at Craibstone. One of these varieties is marked "C" on Table IV. On comparing this with the varieties in Group "B," it was noticed that all the plants were infected with leaf roll, and that the failure was therefore entirely due to this disease.[1] During recent years a great deal of attention has been paid to leaf roll and the conditions under which it is propagated and spread from plant to plant. Plants attacked by leaf roll are usually much smaller than plants unaffected. The lower leaves assume a funnel shape, and become very hard and brittle, and although they still remain green, they do not appear to perform their function properly. The disease is carried on from season to season in the tubers, but, unfortunately, affected tubers cannot be distinguished from unaffected ones. It is believed that the disease is carried from plant to plant by green-fly and other insects, or at all events that the disease is infectious, and will spread from infected plants to non-infected plants. So far, however, as our observations and experiments have gone, we have found no traces of infection at Craibstone. It would seem, therefore, that under moister and cooler conditions, infection does not readily take place. This, again, may be due to the fact that the cool and moist conditions do not favour the development of the green-fly, and, as a matter of fact, we have found very few green-fly on our potato plants. We have grown for several years Kerr's Pink potatoes infected with leaf roll in alternate drills with clean potatoes of the same variety, and we have seen no signs of infection. The following table gives the results of this trial for three years :—

	1920.		1921.		1922.	
	T.	C.	T.	C.	T.	C.
Without Leaf Roll . .	19	14	16	5	19	17
With " " . .	5	6	4	5	5	3

Infected sets and clean sets have also been planted alternately in the same drill, and there has been no sign of any infection.

The failure of some varieties of potatoes that we have grown recently is due, not to leaf roll, but to another disease that is attracting a great deal of attention at the present time, viz., mosaic.[1] In plants affected with mosaic, the leaf has a peculiar variegated colour. The colouring matter in the leaf is largely destroyed, and the leaf, therefore, cannot properly perform its function. It is always noted that plants affected with mosaic ripen prematurely, and their shorter period of growth accounts, to a certain extent, for the reduced yield.

Of the two diseases, however, we find that leaf roll leads to much greater loss than mosaic. Further, with mosaic, as with leaf roll, we find no traces of infection where clean seed is planted alongside infected seed. As in the case of leaf roll, mosaic is carried on

[1] *See* also article on "Potato Diseases," p. 90.

from season to season through the tuber, but here, too, it is impossible to tell affected from unaffected seed.

In 1921, sets from Langworthy plants affected with mosaic were planted alongside sets from unaffected plants, and sets from each of these were again selected for the following year. The crops in the two years were as follows:—

	1921. T. C.	1922. T. C.
Without Mosaic	14 1	14 19
With Mosaic	11 15	9 15

As it is held by some that a badly-nourished plant is much more likely to be attacked by these diseases than a well-nourished plant, we carried out a small trial to find out how far heavy manuring might affect the spread or development of the disease. Two plots were planted, one with clean seed and one with affected seed, and part of each was heavily manured, part had a medium dressing, and part had no manure applied at all. We found there was no infection in the one part more than the other, nor did heavy manuring check the development of the diseases in any way.

Time of Lifting the Crop.—Many growers hold that the use of seed from an early-lifted crop will, to a large extent, counteract the effect of a dry climate, and also prevent the carrying on of such diseases as leaf roll and mosaic from one season to another. Their idea seems to be that comparatively immature sets always produce much more vigorous growth than fully matured sets. We understand that the early lifting of potato sets in dry warm districts has been found to be beneficial. At Craibstone, however, we have lifted crops of some early varieties at different times, but have found no advantage as regards yield in using the early-harvested as compared with the late. Further as regards the diseases mentioned, we have found these quite as prevalent in crops from the early-lifted as from the late-lifted sets.

Table V. gives the returns of seven varieties from one of the experiments from early-lifted as compared with late-lifted sets.

TABLE V.

EFFECT OF TIME OF LIFTING POTATOES ON YIELD.

	Early Lifted.			Late Lifted.		
	Large.	Small.	Total.	Large.	Small.	Total.
	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.	Tons. Cwt.
America . .	15 2	1 6	16 8	14 15	2 12	17 7
Downie's Early .	18 7	1 6	19 13	15 11	0 19	16 10
Edzell Blue .	14 3	1 6	15 9	17 13	1 6	18 19
Ninetyfold .	17 17	1 6	19 3	18 3	1 6	19 9
Dargill Early .	13 3	0 13	13 16	12 16	0 13	13 9
Duke of York .	12 3	1 6	13 9	12 10	0 19	13 9
Immune Ashleaf	12 10	0 13	13 3	16 14	0 13	17 7
Average .	...	...	15 18	...	...	16 13

So far, therefore, as we can see, loss from leaf roll and mosaic can be avoided only by using sets from plants that are entirely free from the disease. It is important to notice, where such selection is to be made, that some plants may be affected only to a very small extent, but that tubers should not be used even from these. If a grower wishes to rear a stock perfectly free from these diseases, his surest and best method will be to make his original selection from single plants about which there is no doubt, and to raise stocks directly from these. Where a large number of plants are thus selected, the tubers from each plant should be planted separately, so that at the end of the season the grower may be able at once to discard any that show the slightest trace of leaf roll or mosaic.

Looking to the results of all these experiments, we may conclude that, if a potato variety is kept pure and free from disease, and is grown under suitable soil and climatic conditions, there need be no deterioration. Further, selection inside the variety itself can effect no improvement as regards yield, quality or disease-resisting powers.

THE FOOD VALUE OF DRIED WHEY SOLIDS.

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AT many cheese factories there is difficulty in disposing of the whey. The great volume produced and the irregular output make it difficult to feed the whole of it to pigs in the immediate vicinity of the factories, and the bulk is so great in proportion to the solid contents that the stuff will not bear the cost of transport.

The solids, however, are rich in the constructive materials required for formation of bone and soft tissues in growing animals. Experiments carried out in America by M'Collum have shown that the protein of whey is much more valuable for growth than that of grains. The salts too are specially suited to the requirements of young animals since the different minerals are present in the proportion needed for growth, while in almost all other foodstuffs there is a deficiency of some and an excess of others. Milk sugar, the third chief constituent, is an easily assimilated carbohydrate which the stomach of the young animal is specially adapted to digest. Hence, though almost the whole of the fat and the most of the protein have been removed from the milk to make the cheese, the residue of the solid matter left in the whey has a very special food value, and it amounts to nearly half of what was originally present in the whole milk. The well-known beneficial effects of feeding whey to young pigs can therefore be easily understood. It is the great bulk of water, amounting to

nearly 94 per cent. of the total amount, that makes it difficult to utilise whey as a feeding-stuff.

At the factory established at Crewe by the Ministry of Agriculture, whey solids and lactalbumen (the protein of whey) can be produced as dry powders. The following table gives an idea of the composition of these products :—

	Protein.	Fat.	Carbohydrate.	Mineral Matter.	Water.
Solids of whey from which fat has been separated.	12	1	69	8	10
Lactalbumen . . .	76	2·5	7·5	3	11

These are concentrated foodstuffs, easily handled. As there is a possibility of them being available as feeding-stuffs it was thought that it would be of interest to make practical tests to determine to what extent the nutritive value of milk is retained in these residues. Through the courtesy of the director of the Government factory at Crewe supplies of them were obtained, and the following experiments were carried out with young pigs at the time of weaning :—

Value of Milk Residues compared with Whole Milk.—In this experiment a mixture of whey solids and lactalbumen was compared with whole milk. A litter of ten pigs, thirty-four days old, was divided into two groups of five each. They were allowed to continue sucking the sow, but three times a day the sow was driven off, and the two groups were separated out. One group was offered whole milk, and the other a mixture consisting of seventeen parts of separated whey solids to two of lactalbumen, the mixture being made up with water to the consistency of milk. The young pigs were allowed to drink as much as they wished, and account was kept of the amount eaten.

During the first week the pigs in the group receiving milk ate more greedily, and put on more weight than those receiving the milk residues, but later those in the group receiving the milk residues ate as well and put on as much weight as those receiving whole milk. At the end of the twenty-eight days there was little difference in the weights as is shown in the following table :—

GAINS IN WEIGHT IN LB.—WHOLE MILK *v.* MILK RESIDUE. PIGS 34–62 DAYS OLD.

	Aver. Weights at beginning.	Aver. Weights at end of 28 days period.	Total Gain.	Average Amount Eaten.
Whole Milk .	20·2	38·7	18·7	Milk 61 lb.
Milk Residues .	20·9	38·7	17·8	Lactalb. 1½ lb. Whey Solids 8 lb.

All the animals were in a thriving condition at the end of the experiment, when they were completely weaned and put on a

mixture of maize, oatmeal and fish meal, on which they continued to thrive. During the first week after complete weaning, *i.e.*, in their tenth week after birth, the group that had been weaned on the milk residues put on, on an average, 1·16 lb. each per day, and the group that had been weaned on whole milk 1·19 lb.

During the twenty-eight days each animal getting the milk residues ate, on an average, 8 lb. of whey solids and 1·5 lb. of lactalbumen. As these contained about 10 per cent. of water, the total dry matter was about 8·6 lb. In the group getting whole milk each pig ate on an average 61 lb. of whole milk, that is about 7·8 lb. of dry matter. Compared with the milk residues, therefore, the whole milk gave slightly greater gains for a slightly smaller quantity of dry matter eaten, which is what would be expected when it is remembered that the residues contain such a small proportion of fat compared with the solids of the whole milk.

Value of Whey Solids compared with Skimmed Milk.—This experiment was devised to test the value of adding (1) whey solids and (2) skimmed milk to a ration consisting of equal parts of maize, oatmeal and sharps. A litter of fifteen pigs was divided into five groups of three each. Three of the groups were used for this experiment, the other two being reserved for an experiment with other feeding-stuffs not connected with milk. The whole fifteen were allowed to suckle during the twenty-eight days of the experiment. As before, the young pigs were separated from the sow and fed three times a day. One group received the meal mixture only, another a ration of equal parts of the meal mixture and whey solids, and a third a ration consisting of the meal mixture and skimmed milk in the proportions of 3 lb. of the former to 28 lb. of the latter. There is about the same quantity of dry matter in 28 lb. of skimmed milk as in 3 lb. of whey solids, so that the rations with skimmed milk and whey solids were comparable as regards solids contents. The results are shown in the following table :—

	Average Gain in Weight.	Food Eaten per Animal—lb.	
	Lbs.	Meals.	Skimmed Milk.
Skimmed Milk plus Meals .	17·0	17·8	123·6
		Meals.	Whey Solids.
Whey Solid plus Meals .	15·4	11·7	11·7
		Meals.	
Meals only	10·8	22·5	

The beneficial effects of adding whey solids to meals are very apparent. An average gain in weight of 15·4 lb. was got in the animals which received 23·4 lb. of the half and half mixture of meals and whey solids, whereas only 10·8 lb. gain was obtained in the animal that ate on an average 22·5 lb. of meals. A comparison of the influence of the skimmed milk with the whey solids is not so clear. Those receiving the skimmed milk put on rather more weight, but they ate more food in proportion to the gains. As a whole, the experiment is a demonstration of the very special

value of the constituents of milk for feeding young animals, and proves that whey solids as an addition to a meal ration enables much better utilisation to be made of the ration.

Other experiments were carried out to show the value of lact-albumen and the comparative value of whey solids and dried egg which is sometimes available as a feeding stuff. The results, which need not be detailed here, were, in general, the same as those recorded above. The addition of comparatively small amounts of these substances to a ration for young animals has a marked effect on the rate of growth.

Taken together, these experiments bring out clearly the special value of milk residues for growing animals. Milk is a fluid specially prepared by nature to yield constructive material for formation of bone and soft tissues. Whey solids contain nearly half of the solid material originally present in the milk. It is not surprising, therefore, that the addition of this material to the ration of young animals results in increased rate of growth.

The whey solids used in the experiments were obtained from whey from which the fat left after the cheese-making had been removed, so that only a small amount was left. In the solids from unseparated whey there is about five times as much fat as is present in those from separated whey. No experiments were made with unseparated whey solids, but one would think that these being richer in fat would have given still better results.

Experiments with calves would be even more interesting than those with pigs. The milk of each species is specially adapted to the requirements of the young of that species. The ratios of the different tissue and bone-forming elements found in cow's milk are different from those found in sow's milk. One might expect, therefore, that whey from cow's milk would be more suitable for calves than for young pigs. Experiments to put this supposition to the practical test are in progress here.

The possibility of utilising whey solids for compounding a food for infants after weaning is worth while considering. The period between six and eighteen months of age is a critical one in the feeding of children. At this stage it is a common practice to begin giving foods made from cereal grains. These are deficient both in the quantity and in the quality of the proteins, and markedly deficient in the amounts and proportions of the various minerals necessary for health and growth. Milk added to these foods helps to correct the deficiencies, and to save the child from diseases of malnutrition, such as rickets. According to the results of the first experiments recorded here, dried whey solids should be almost as valuable as dried whole milk. The constituents most deficient in the solids are fat and the vitamin associated with fat. The deficiency of fat-soluble vitamin could easily be made good with the addition of small quantities of cod-liver oil. If whey solids were found to have the same excellent influence on the nutrition of infants as has been found in the experiment on growing pigs referred to here, the material is too valuable to be

used as a feeding-stuff for farm stock. The whole of the whey output from cheese factories could be utilised for human food to the profit both of the factory and of the consumer. There is urgent need of a cheap food for children after weaning. The whole question of the availability and utilisation of whey solids for this purpose might well form the subject of a joint enquiry by the physiologist, the medical clinician and the manager of the cheese factory.

According to Golding of the National Dairy Institute, the production of whey in this country is estimated at 100 million gallons, and of this one half is wasted. At cheese factories the loss is as high as 75 per cent. It seems a pity that this valuable material, instead of being completely utilised, is allowed to run to waste to the pollution of the country side. The writers have no data from which the cost of drying can be calculated, nor is it easy to estimate in money the worth of the dried material per pound. There is no doubt, however, but that the nutritive value of the dried material warrants a considerable expenditure on its preparation. If the Lactose Factory at Crewe can devise means of putting dried whey solids on the market at a reasonable price, it will have performed a valuable public service.

THE LAYING DOWN OF TEMPORARY PASTURES.

WITHIN the past twenty years or so a vast amount of valuable information has been gleaned from various sources regarding the laying down, maintenance and improvement of all classes of grass land. This fact is of extreme significance at a time like the present when farmers all over the country are adding to the area of grass land either by sowing down land to permanent pasture or by allowing the temporary leas to remain unbroken for longer periods. As illustrating this latter fact it may be mentioned that during the past year no less than 33,300 acres were added to the area under temporary pasture in Scotland.

It must not be supposed, however, that all this information has been acquired but recently. For instance it is illuminating to read the essays written by an Aberdeenshire farmer, James Anderson, Monkshill, Udny, about the year 1776. He deals largely with the habits and agricultural value of the different grasses and clovers. Perennial rye grass he considers to be an indifferent grass for pasture. It is in his opinion short-lived and after flowering produces few green blades while the heads are disliked by stock. He commends the poas and the fescues on account of their ability to produce succulent green leaves throughout the summer. Leguminous plants in particular he commends. "No other class of plants afford such nourishing food for quadrupeds as this does."

He condemns the then common practice of allowing lands to clothe themselves with such plants as chose to tenant the ground in the hope that sooner or later pasture of some kind would be established. He tells us too that the practice of sowing grass and clover seeds was introduced into Britain some hundred years before and he is, of course, a sincere believer in this system.

If we try to discover, by reference to agricultural text books or seedsmen's catalogues what constitutes a good pasture we find a bewildering display of different plants all of which would seem to be indispensable. On the principle that safety lay in numbers seed mixtures used to be made up from the seeds of many different plants irrespective of the fact that many of these plants did not suit Scottish conditions. Nor was it realised that the inclusion of a relatively inferior plant might prejudically affect the development of the superior plants. The relative effects of the different plants on each other were never studied. Consequently seed mixtures frequently included seeds of grasses that never grew, and did not include the seeds of grasses and clovers that would grow. What the farmer wants when he lays down his temporary mixture is:—

(1) A good first year's crop for hay or pasture.

(2) A plentiful pasture in the following years which is liked by stock, continues to grow throughout the summer and which, when ploughed up, leaves the land clean and in good heart.

The number of forage plants which some authorities consider do give first class results is small. The principles on which these authorities make up their mixtures are as follows. They consider—

(1) What grasses and clovers are best adapted for giving bulk the first year or two.

(2) What grasses and clovers are best suited to follow on and are likely to produce abundant, palatable and close-soled pastures.

Having determined these they proceed to make up their mixtures by proportioning the different seeds in a ratio which is arrived at empirically.

The following plants are usually considered to be the most important:—

Grasses. PERENNIAL RYE-GRASS.—This grass ought to be included in all temporary grass seed mixtures. Various points require to be noticed.

Length of Life.—This grass, which reaches its maximum development in the year after it has been sown and is hence suited for hay, usually lives from three to five years only. It is perennial only on certain soils and under conditions which do not admit of its flowering. By itself it is unsuitable for such pastures as are laid down for three years and upwards. Associated with slower growing grasses and clovers it is extremely valuable for such temporary and permanent mixtures. The accompanying diagram which is based on figures obtained from experiments carried out

by Findlay (Aberdeen) shows how the perennial rye-grass tends to die out, its place being filled by cocksfoot and timothy.

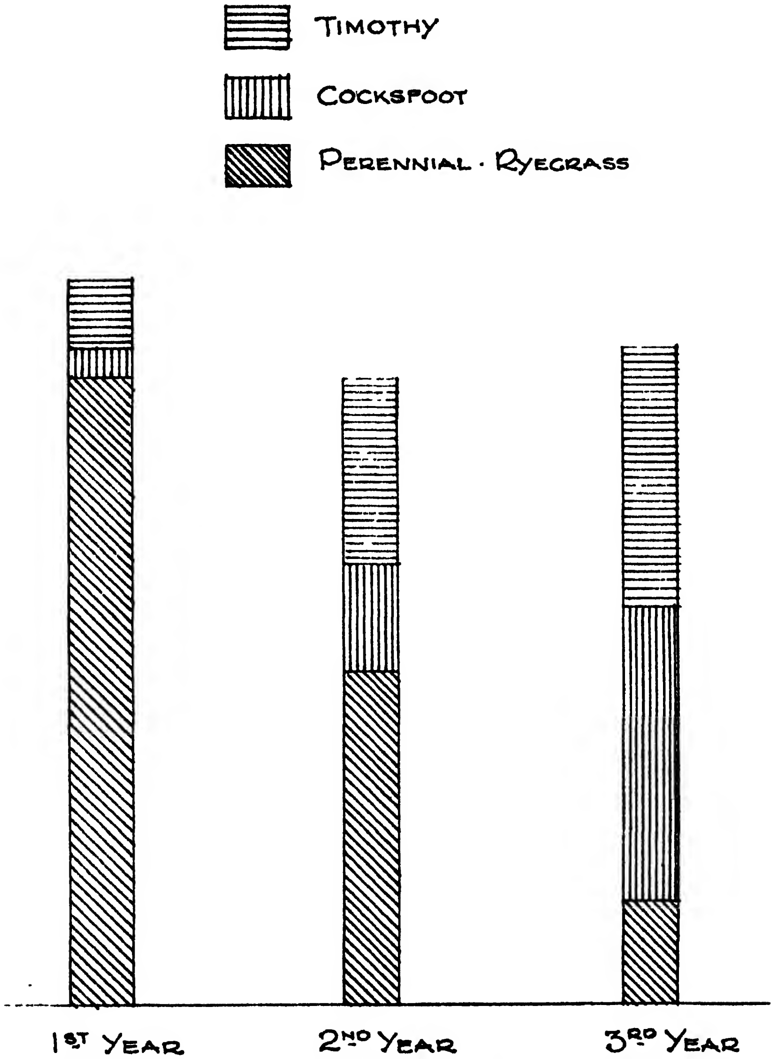

Diagram showing relative amounts (by weight) of Perennial Rye-Grass, Cocksfoot and Timothy in 1st, 2nd and 3rd Years' Grass respectively.

Bulk and Feeding Value.—From the point of view of bulk and feeding value perennial rye-grass is one of our most valuable hay grasses. Especially is this the case when associated with red clover in hay. For pasture purposes perennial rye-grass is also valuable. It comes away early in the spring and again in autumn producing a considerable amount of succulent leaves. After flowering, especially if the summer be dry, it produces few leaves while the flower heads are disliked by stock. Hence the desirability

of its being associated with forage plants which continue to grow throughout the summer.

Influence on other Grasses.—If sown in quantities exceeding 16 lb. per acre along with seeds of cocksfoot and timothy it has a distinct tendency to crowd out or unfavourably affect the development of these grasses. Its influence in this respect on meadow fescue is so marked that meadow fescue plants can rarely be seen where 16 lb. or upwards of perennial were included in the mixtures.

Influence on Clovers.—Perennial rye grass if used in considerable quantities has a prejudicial effect on red clover. Findlay (Aberdeen) records the following experiment:—

Seeding.	Weight of Clover in Hay. Cwts.
1½ Bushels Rye-Grass with Red Clover . . .	19·4
½ Bushel Rye-Grass with Cocksfoot, Timothy and Red Clover	24·3

This prejudicial effect is aggravated if the hay crop is top dressed with quick-acting nitrogenous manures.

Influence on Weeds.—On most soils perennial rye-grass is short lived and unless provision is made for the place of the dying plants being occupied by valuable natural grasses and clovers the empty spaces quickly become filled up with self-seeded plants. Frequently these are worthless grasses and weeds. Light, thin, peaty soils generally become a mat of pluff grass, creeping bent, etc., unless suitable long-lived grasses and clovers have been used in the mixture.

Root System.—Perennial rye-grass has a shallow root system. Consequently it is unfavourably affected by periods of drought. Stock feeding on rye-grass pastures frequently fail to put on any weight during July and August.

ITALIAN RYE-GRASS. *Length of Life.*—This grass is a biennial, but under very favourable conditions it may survive for a considerable number of years. Hence, if sown in mixtures intended to remain down for two years and over it must be associated with longer-lived grasses and clovers.

Bulk and Feeding Value.—Italian rye-grass comes very early in the spring and produces a large bulk of succulent leaves and flower heads. It is more adapted for hay or cutting purposes than for pasture. Its long hollow stems are deceptive in appearance in a hay crop. Farmers usually over-estimate the weight of hay when Italian rye-grass is present and under-estimate the weight of a crop containing perennial rye-grass and clover. It is an extremely useful grass for catch-cropping and soiling purposes.

Influence on Clovers.—Italian rye-grass has usually a prejudicial effect on clovers due to its broad leaves and early habit of growth checking the development of the young clover plants. Findlay

(Aberdeen) records the following experiment as an example of this:—

	Mixture.	Weight of Clover. *Cwts.*	Weight of Hay. *Cwts.*
No Dung.	20 lbs. Perennial, with other Grasses and Clovers .	25·7	43·6
	20 lbs. Italian, with other Grasses and Clovers .	10·5	37·5
With Dung.	20 lbs. Perennial, with other Grasses and Clovers .	22·6	59·6
	20 lbs. Italian, with other Grasses and Clovers .	6·6	44·1

The effect of replacing 4·2 lb. of perennial rye-grass in a mixture containing 20·4 lb. of that grass by 5·8 lb. Italian (the estimated number of seeds was the same) was to reduce the clover in the hay from 15·2 to 11·8 cwt. These trials were carried out under conditions which apply generally to the north of Scotland.

In view of these considerations it is doubtful if Italian rye-grass should be included in any grass seed mixtures except in the case of good heavy soils which are well adapted for its growth. On light, dry lands its use is not justified by results.

COCKSFOOT. *Length of Life.*—Cocksfoot is a slow-maturing perennial grass. Its value in mixtures of short duration depends largely on soil and climate. While in some cases, it produces a fair bulk in the second year's grass, in other cases the yield is small. Associated with perennial rye-grass in mixtures of three years and upwards it is extremely valuable.

Bulk and Feeding Value.—So far as bulk is concerned cocksfoot is one of the best pasture grasses. It comes early, grows rapidly and if not allowed to get rank and tufty, continues growing throughout the summer and autumn. It is more suited for pasture than for hay.

Effect of Thin Sowing.—Cocksfoot if sown in small quantities especially along with perennial rye-grass is apt to go readily into ear and to form unsightly tufts which are disliked by stock. When larger quantities are sown the plants tend to produce a larger proportion of leaf blades.

Effect on Wild White Clover.—If allowed to grow too luxuriantly cocksfoot has a bad effect on wild white clover. This effect is seen frequently in fields where cattle have been cake-fed or in places where cattle have lain a great deal.

TIMOTHY. *Length of Life.*—Timothy like cocksfoot is a slow-maturing perennial. Its inclusion in grass seed mixtures of three years and upwards is warranted by the comparative cheapness of its seed, its value as a bulky forage grass and its high feeding qualities. It is not adapted for growing in dry sandy soils.

OTHER GRASSES.—Tall oat grass is one of the few other top grasses which may be used for temporary pastures. Its use is warranted only on dry soils where difficulty is experienced in

growing timothy. Unless in the early spring it does not appear to be much relished by stock. For a reason already given the inclusion of meadow fescue in a mixture frequently means that money is thrown away. The use of such grasses as meadow foxtail and tall fescue in temporary mixtures is seldom warranted. They possess no advantage over cocksfoot while the seed costs more. Wherever wild white clover can be grown the sowing of bottom grasses is generally not warranted by results.

Clovers. RED CLOVER.—Red clover which is classified into two kinds, the ordinary broad-leaved clover and the late-flowering red, should be included in all mixtures. The latter, as its name indicates, is later in flowering than the broad-leaved and produces less aftermath. A taller, more bulky plant, it is more suited for cold districts, is adapted to a wider range of soils and is longer lived than the common variety. In all probability it has been derived by the continuous natural selection of those plants of ordinary red which survive in the colder and wetter districts. The following points should be noticed. Ordinary red clover often fails either wholly or partially. This may be due to:—

1. *Nationality of Seed.*—The colder the climate of the country of origin of the seed the more likelihood is there of the plants surviving our winters. Findlay found the following results in certain trials in which red clover seed of different nationalities was used in an otherwise complete mixture:—

Nationality.	Average Weight of Clover.	Average. Weight. of Hay.
Broad leaved English Clover .	26·9 cwt.	45·1 cwt.
Average of Canadian, Chilian, French and German Clovers	12·9 „	33·3 „

2. *Physical condition of Soil at time of Sowing.*—If the soil is too lumpy, too loose or too dry, the clover seed frequently fails to germinate. Land from which turnips have been removed late in the spring, and which, when ploughed, is both dry and loose, frequently fails to grow good clover plants. On the other hand, land which has been ploughed early and has consolidated, *e.g.*, potato land, often produces a fine take of clover.
3. *Competition of the Grain Crop.*—One of the reasons why clover grows so luxuriantly about gateways is the absence of competition with grain crop. As a nurse crop the oat crop is not so well suited as either the wheat or the barley crop. The straw-producing varieties of oats are less well adapted for the growth of the young clovers than the grain-producing varieties.
4. *Lack of Lime and Potash.*—The deficiency of suitable quantities of these ingredients is often the cause of the relative failure of clover to grow.

5. *Competition with Quick-Growing Young Grasses.*—The use of Italian rye-grass unless in very small quantities is generally prejudicial to the growth of clover. Excessive quantities of perennial have the same effect.
6. *Use of Stimulating Nitrogenous Manures.*—Stimulating nitrogenous manures, used alone, give the quicker growing grasses too great an advantage over the slower growing clovers.
7. *The Effect of Pasturing Sheep.*—If sheep are pastured on young red clover plants grown in clay soils, during wet weather in winter, bad effects usually follow. Harm is often done by the close grazing of young seeds hay in the late spring. If the plants are eaten too bare they seem to get a set-back from which they have difficulty in recovering.
8. *Effect of Frost.*—In light land alternate frosts and thaws frequently have the effect of throwing out the clover plants. Rolling in dry weather in autumn tends to prevent this. Late-flowering red is less apt to be thrown out than ordinary red.
9. *Methods of Sowing.*—In sowing clover seed it is desirable that the seed should not be at a greater depth than is consistent with its getting sufficient moisture to enable it to germinate. Close packing of the ground which can be obtained on light and peaty soils by rolling both before and after the seed has been sown is helpful. It is also desirable to use light harrows only on such soils. Sowing the grass and clover seeds after the grain crop has brairded, is frequently beneficial, but is not advisable in very dry springs.

Pests.—The failure of the growth of clover plants is frequently said to be due to "clover sickness." This term, however, does not stand for any one definite disease. Eel worms are one undoubted cause of "clover sickness." Another, and one usually associated with eel worms, is a fungus disease which attacks strong-growing plants during a long spell of wet weather in the autumn and winter. Grazing by sheep in autumn to reduce the thick foliage, and the drainage of wet ground, are preventive measures against attacks of "clover sickness." Alsike is less subject to the disease than red clover.

Ordinary Red compared with Late-Flowering Red.—The latter usually gives the largest weight of hay, but less aftermath. Findlay found the following results in a series of experiments :—

	Weight per Acre.	
	Clover.	Hay.
Ordinary English Red . . .	26·8	45·1
Late-Flowering Red . . .	35·9	52·1

It should be noted that late-flowering red, if sown in considerable quantities, prejudicially affects the growth of other grasses

and clovers. On account of its coming into flower some ten days or a fortnight later than the ordinary red, farmers are often tempted to delay the cutting of the hay crop in order to secure bulk—a proceeding which may spoil the quality of the hay owing to the rye-grass being over-ripe. Usually it is better adapted for growth in Scottish soil than the ordinary red.

ALSIKE.—A native of Sweden, this clover, which is often incorrectly thought to be a hybrid between the ordinary red and white clovers, should have a place in most seed mixtures for Scottish soils. It suits cold, moist conditions better, is less subject to disease and is more lasting than red clover. As its seed is very much smaller the quantity sown per acre should be considerably less than the quantity of red clover.

WHITE CLOVER.—Ordinary commercial white clover is a short-lived plant more adapted for pastures than for hay. Its value in a grass seed mixture has been greatly discounted of late years. It appears to have a prejudicial effect on wild white clover, and on this account should not be largely made use of in mixtures which are intended to lie down for more than two years.

WILD WHITE CLOVER.—Wild white clover is now recognised to be one of the most important ingredients in all pastures of a more or less permanent character. Its value is due to various circumstances. When once established it quickly spreads by means of its long creeping stems which spread out and root in the same way as strawberry runners do. In this way it quickly tenants all vacant spaces, and effectively checks the growth of such weeds as Yorkshire fog and bent grass. Its leaf blades, leaf stalks, flowers and flower heads are not only well liked by stock, but are also full of valuable feeding material. Few plants seem to stand tramping so well as wild white clover. Its ability to utilise and to store up in the soil the free nitrogen of the air enables farmers to build up the fertility of their land at the minimum of cost. On certain lands it responds so freely to top dressing of basic-slag, that what would otherwise have been comparatively poor pasture land is now some of the richest grass land in the country. Usually it takes at least two years to establish itself, but this is dependent to a certain extent on whether a first year's hay crop has been taken or not. Pasturing the first year's grass favours its development. Owing to the enormous demand in recent years for wild white clover seed the ruling prices have been high. In spite of this many farmers consider that it pays to include the seed in mixtures intended to lie down for only two years. For mixtures of two years and upward it is practically indispensable.

The seeds of several other plants, leguminous and otherwise, are recommended by various authorities for inclusion in temporary seed mixtures. In view of either their relatively high price or the fact that the resulting plants may be competing with other plants of superior feeding value, the economy of sowing them is doubtful.

Method of Making Grass Seed Mixtures.—(*a*) Relative area devoted to grasses and clovers.

As already stated the methods of determining what proportion of land ought to be devoted to grasses and clovers are largely empirical. In temporary mixtures, which are to be down for three years and upwards, the following proportions have generally been found to give very good results :—

	Percentage of Ground Covered by each Species.
Short-Lived Grassses	25 per cent.
Long-Lived Grasses	55 ,,
Clovers	20 ,,

These percentages are again subdivided in proportioning out the different kinds of grasses and clovers. The following examples may be quoted :—

		Percentage of Ground Occupied by each Species.
Short-Lived Grasses.	Perennial Rye-Grass	25 per cent.
Long-Lived Grasses.	Cocksfoot . .	27½ ,,
	Timothy . .	27½ ,,
Clover . . .	Ordinary Red Clover	5 ,,
	Late Flowering Red	5 ,,
	Alsike . . .	6 ,,
	Wild White . .	4 ,,

Amount of Seeds required to Sow an Acre.—The quantity of seeds per acre used by farmers varies considerably. Thus some farmers use as few as seven millions of seeds per acre, while others use as many as fifteen millions. Under ordinary conditions the thicker sowings are usually found to produce no better results than the thinner sowings. Care must be taken, however, to ensure that a sufficiency of plants is left in the event of the young grasses and clovers encountering adverse conditions, such as the lodging of the nurse crop, etc. Ten million seeds per acre may be counted upon to give satisfactory results.

In order to illustrate the distribution of the various seeds when sowing mixtures at the rate of ten million seeds per acre, and in the above proportions it may be mentioned that in a piece of ground the size of a page of the *Journal* the approximate numbers of the different seeds sown would be as follows :—

	No. of Seed.	Approximate Rate of Seeding per Acre. *Lbs.*
Perennial Rye-Grass	23	14
Cocksfoot	25	6
Timothy	25	2·5
Ordinary and Late-Flowering Red Clover	9	5
Alsike	6	1·25
Wild White	4	·5

Examples of grass seed mixtures for leas of three or four years' duration:—

	LB. PER ACRE.		
	Light Soil.	Medium Soil.	Heavy Soil.
Perennial Rye-Grass	14	14	14
Cocksfoot	9	7	7
Timothy	2	3	4
Ordinary Red Clover	2	2	2
Late-Flowering Red	2	1½	1½
Alsike	...	1	1
Wild White	½–1	½–1	½–1

TWO YEARS' LEYS.—The above mixtures may be adapted for two-year leas by reducing the quantity of cocksfoot to some 3 or 4 lb. The quantity of rye-grass may be increased by a like amount or some 3 lb. of Italian added to the mixture. Ordinary white clover may be included to the extent of ½ lb. Wild white should not be sown in excess of this amount.

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Inspection of Potato Crops in 1922.

IN 1922 the Board offered inspection of growing crops of potatoes in order to enable growers and merchants (1) to meet the provisions of the Seeds Act, 1920, and the Seeds (Scotland) Regulations, 1922, which prescribe that seed potatoes sold under a particular name or description (*e.g.*, Kerr's Pink) must be true to that name or description to the extent of, at least, 97 per cent., or, if they are under that percentage, that a statement must be

made to the effect that they consist of mixed varieties; (2) to meet the requirements of the Imported Scottish Seed Potatoes Order of 1920, which prohibits the importation into England of any seed potatoes of the immune varieties from a crop grown within a mile of a place where an outbreak of wart disease has occurred, unless the crop has been found on inspection to be sufficiently pure to qualify for the certificate of purity known popularly as the I.V. Certificate; and (3) to ensure a supply of seed potatoes of reasonable purity for planting in land known to be infected with wart disease or scheduled as an infected area.

The tables on this and the following page show the total acreages of the varieties inspected, and indicate the strength of the demand for inspection as well as the general state of the potato crops in Scotland in respect of purity:—

SUMMARY OF ACREAGES OF POTATO CROPS INSPECTED FOR PURITY IN SCOTLAND DURING 1922.

I.—Immune Varieties.

Varieties.	Total Area in Scotland.	Total Area Inspected.	Grade of Purity. *99·5% and above.	Below 99·5% to 97%.	Below 97%.
	Acres.	Acres	Acres.	Acres.	Acres.
Great Scot . .	11,368	4,892	3,411¼	994½	486¼
Kerr's Pink . .	11,326	4,071	3,243½	528¾	298¾
Tinwald Perfection .	5,125	2,729¼	2,637¾	249	112½
Majestic . . .	2,773	2,168¼	1,491	402½	274¾
Golden Wonder .	7,862	2,027¼	1,758½	207¼	61½
Arran Comrade .	3,939	1,251¾	1,073¼	65¼	113¼
Crusader . . .	1,850	1,222½	1,168¼	38¾	15½
King George . .	1,368	639¼	404¾	172	62½
Ally . . .	915	634¼	303¾	158	172½
Lochar . . .	1,174	538¼	461¼	35	42
Langworthy . .	2,642	366¾	148½	134¾	83½
Abundance . .	2,329	288¼	187½	42½	58¼
Rhoderick Dhu .	330	231¾	225	4¼	2½
Arran Victory . .	962	230½	217¼	4¼	9
Witchhill . .	164	128¾	87½	30¼	11
Dargill Early . .	167	120½	105¼	6½	8¾
Immune Ashleaf .	67	65½	41¼	13½	10¾
Others . . .	4,151	799½	663½	70¾	65¼
TOTALS .	58,242	22,405¼	17,359	3,157¾	1,888½

* Stocks reaching this grade of purity qualify for the "I.V. Certificate."

STOCK SEED.—With a view to encouraging the development and distribution of stocks which are of a high state of vigour and purity, inspectors were instructed to report specially any crops noted as exceptionally pure, grown in conditions ensuring continued purity, and free from diseases carried on seed tubers or perpetuated by seed, *e.g.*, Corky Scab, Mosaic, Leaf Roll and Blackleg. Reference to the article on page 54 of this issue indicates the possibility of freeing Scottish stocks of potatoes from constitutional diseases like Leaf Roll and Mosaic.

The crops recommended were visited at least three times, and the greatest care possible was exercised in ensuring that the stocks

II.—Non-Immune Varieties.

VARIETIES.	Total Area in Scotland.	Total Area Inspected.	Grade of Purity.		
			97% and above.	Below 97% to 94%.	Below 94%.
	Acres.	Acres.	Acres.	Acres.	Acres.
King Edward . .	20,276	7,492	5,766¾	823¾	901½
Arran Chief . .	29,473	4,384¼	2,869¼	591	924
Eclipse . . .	1,947	1,250¼	997½	173¼	79½
Epicure . . .	10,322	935¼	669¼	170½	95½
Sharpe's Express .	1,070	671¼	556	46¼	69
British Queen . .	5,803	661¼	493	79½	88¾
Midlothian Early .	1,762	573¼	439¾	51½	82
Evergood . .	736	448	334¾	64	49¼
Up-to-Date . .	4,598	220¾	114¾	40¾	65¼
Iron Duke . .	996	105½	75¾	7	22¾
Field Marshal . .	243	97½	96¼	¾	½
Others . . .	4,046	724¾	609	58	57¾
TOTALS .	81,272	17,564	13,022	2,106¼	2,435¾

thus selected for special mention were of the highest quality for stock seed purposes.

The final recommendations in respect of these select stocks is summarised in terms of varieties and acreages as under :—

Immune Varieties.	Acreage.
Kerr's Pink	3
Majestic	3
Crusader	22½
Tinwald Perfection	46
Golden Wonder	5
Dargill Early	½
Rhoderick Dhu	1
Great Scot	1

Non-Immune Varieties.	Acreage.
King Edward	124½
Arran Chief	4¾
Up-to-Date	6½
Duke of York	4¾

The total acreage of potatoes in Scotland was 139,514. The total acreage inspected was approximately 28·5 per cent. of that area.

In 1921, only immune varieties were inspected, but in 1922 arrangements were made for inspection of all varieties. Of *immune varieties* the area inspected in 1922 was 5745 acres less than in 1921. This is a much larger decrease than the decrease in the actual acreage planted.

In 1921, 81 per cent. of acreage inspected was certified.
" 1922, 77 " " " "

The acreage of immune varieties certified after inspection to be over 99·5 per cent. pure is 77 per cent. of the inspected acreage or 30 per cent. of the total acreage. The acreage known after inspection to be below 97 per cent. pure is approximately 9 per cent. of the inspected acreage.

The acreage of *non-immune varieties* known after inspection to be over 97 per cent. pure is 74 per cent. of the acreage inspected, or expressed in terms of the total acreage, 16 per cent.

NOTES ON THE VARIETIES.—*Great Scot* shares with Kerr's Pink the distinction of being the most popular immune variety. The percentage of the inspected acreage of Great Scot certified is 70. This percentage is equal to that of last year.

Kerr's Pink.—The percentage of certified stock to stock inspected is reduced as compared with 1921. This reduction is partly due to certain spurious stocks having been distributed in 1920 and 1921, and to the non-detection of some of the spurious stocks which are difficult of identification: it is also partly accounted for by the fact that the variety has become mixed with certain other red-skinned varieties which are similar to it, and that several of these rogues had not been identified as distinct from Kerr's Pink in previous seasons. The Board have made every endeavour to trace all crops of the spurious and mixed stocks, and believe that their further distribution will now be checked.

Majestic.—There is an increase of 500 acres in the inspected acreage of this variety as compared with last year. The popularity of Majestic during last season in England was indicated in the price of the seed during spring, and has a reflex in the increased acreage in Scotland. The general standard of purity of the stocks has improved, the percentage of crops certified to those inspected this year being 69 as compared with 62 per cent. last year.

Golden Wonder.—The acreage of this variety entered for inspection has increased from 1287 in 1921 to 2027 this year. This variety has always been extensively grown in Scotland, being a popular potato on account of its excellent culinary quality, and in consequence commanding a much higher ware price than all other varieties during the past two seasons. Hitherto only a comparatively small acreage has been entered for inspection. This year 26 per cent. of the total acreage has been inspected. The standard of purity has also improved: 87 per cent. of the acreage inspected was certified as compared with 80 per cent. last year.

Tinwald Perfection.—946 acres more of this variety were grown this season than last, and 350 acres more were inspected than in 1921. The variety is finding favour as a ware potato, being of good culinary quality.

Arran Comrade.—The popularity of this variety has declined rapidly in the last two years, owing chiefly to its tendency to grow tubers too small for ware. There is a decrease of no fewer than 1750 acres in the acreage inspected. The standard of purity has also deteriorated. The percentage rates of certified to inspected crops in 1921 was 90; this year it is 86.

Crusader.—This variety was not entered separately in last year's statistics of potato crops inspected. The total acreage grown in 1920 was 130, this year it is 1580, of which 1222½ acres were inspected. It is gratifying to observe the high standard of purity of the crops inspected, which reflects the great care taken by the original holders to ensure that a true stock was issued for general distribution. It is hoped that growers will continue to exercise the greatest care in handling to prevent mixing now.

King George, Ally, Lochar.—These varieties, which in the earlier years of the potato inspection scheme were extensively cultivated, appear to be going out of favour: Ally because of lack of pure stocks and on account of poor quality in Scotland, where it is grown chiefly as a seed crop for the use of English growers; King George and Lochar because of bad quality and lack of demand for seed of these varieties in England. As in previous years the stocks of King George are reasonably pure, those of Ally are badly mixed—more than half the acreage inspected being unfit for certification—and those of Lochar are very pure.

Rhoderick Dhu.—This is another new variety not previously included in the list of varieties inspected. The stocks are evidently not large, but are well distributed throughout the potato growing areas. The standard of purity is very high.

Arran Victory.—The standard of purity of the crops of this variety is very high, but its popularity seems to be declining. The acreage planted this year is 20 per cent. less than that of 1921.

Witchhill and Dargill Early.—The stocks of these varieties are being maintained, but neither variety has apparently made a wide appeal. The stocks of Witchhill are rather badly mixed, only 68 per cent. of the acreage inspected being fit for certification. The Dargill Early stocks are on the whole pure, 87 per cent. of the total acreage inspected being certified. The fault of Witchhill is its liability to blight, while Dargill is not a true first-early.

Abundance.—While the total acreage of this variety is considerable, the quantity offered for inspection is small, being only 12½ per cent. of the total crop grown. This may be due to the fact that, having been long in cultivation, stocks are generally impure. A considerable proportion of the inspected stock of this Abundance was entered under the newer names for this variety, *e.g.*, Kerr's New White, Laing's Prolific, Osborne Seedling.

RELATIVE PURITY OF VARIETIES.—Incidental to the work of inspection a statistical questionnaire was filled in by the Inspectors engaged. Some interesting information has been collected from the replies (31 in all). Ally and Majestic are the varieties which most frequently contain rogues to an extent above ½ per cent. Next in order but a long way behind is Great Scot, while the fourth on the list is Kerr's Pink. The early varieties, Witchhill and Immune Ashleaf, also frequently contain more than ½ per cent. of rogues.

Of the Non-Immune varieties Arran Chief is the most frequently mixed with more than 3 per cent. of rogues. King

Edward follows closely. Epicure, Eclipse and British Queen contain above 3 per cent. much less frequently.

The three most common rogues in stocks of all kinds are Up-to-Date, Arran Chief and Early Market. Much less frequent are in order: British Queen and Northern Star, while Evergood, Wilding varieties, and King Edward form a third group of varieties occurring with much less frequency than the second. Champion is the only other variety reported a few times as occurring with some frequency as a rogue.

The rogues in first early non-immune varieties appeared to be the common first early varieties and Myatt's Ashleaf, while the common late sorts also occur frequently. The presence of Royal Kidney is frequently noted. Conquest and some unidentified rogues are found in Epicure. Myatt's Ashleaf is most often reported as occurring in north country stocks of Duke of York. One stock of Sharpe's Victor is mixed with a white-fleshed type. Witchhill occurs in Duke of York.

The reports of the occurrence of rogues were remarkably uniform.

POPULARITY OF VARIETIES.—During the course of the inspection enquiries were made regarding the popularity of varieties, and the information reported by them is in accordance with the information conveyed by the acreage returns for this year, namely, that King Edward and Arran Chief are easily the most popular varieties, and that the demand is greatest for these two sorts.

Immune varieties are grown largely for the English seed market, though Kerr's Pink, Great Scot and Tinwald Perfection are finding favour as ware in some places. Golden Wonder is the acknowledged best for quality. There would be a greatly improved demand for Majestic, and to a less extent Ally, if the quality of these varieties was good, and if the stocks were reasonably pure.

The question of immunity does not concern the farmer unless he is situated in a scheduled area, but there is no doubt that immune varieties to take the place of Arran Chief and King Edward would be welcomed.

Land Drainage.

PRACTICAL agriculturists everywhere speak of the dire need of drainage throughout the country, but admit that failure to drain during the last forty years or so has generally been due to the high cost as compared with the resulting returns. Fostered by Government loans and encouraged by cheap labour on the one hand, and high prices for all kinds of agricultural produce on the other, land drainage reached its highest period of development during the middle decades of last century. Since then little has been added to the area of drained land, while the existing drains in many instances,

owing either to age or to neglect have become comparatively useless. The effect of the war-time period of prosperity, which would probably have been to encourage land drainage, was counteracted by the lack of labour. The consequence was that at the end of the period of hostilities the country was in greater need of drainage than ever. It is true that the abnormal conditions set up by the war stimulated mechanical drainage. Several promising machines have been put on the market, but for all practical purposes land drainage by such means may still be considered to be in its elementary stage.

Last winter a considerable amount of land drainage was undertaken under the Government scheme for the relief of unemployment which was administered by the Board of Agriculture for Scotland, and a similar scheme is again in operation this winter. Taken all over the scheme proved itself to be not only an exceedingly useful way of alleviating distress, but also a highly popular scheme amongst farmers. It was interesting to note that several farmers and small holders invested in land drainage the whole of the corn subsidy money they received. Altogether, 266 schemes were approved, involving a total expenditure of over £40,000, and employing about 1400 men. Three main classes of drainage work were carried out—

1. Field drainage.
2. Hill drainage.
3. Repairs to embankments and the cleaning out of main ditches.

Field Drainage.—Generally speaking, in the mainland counties tiles were used. Occasionally where soft bottoms were encountered these were laid on wood, and in certain cases heather, rushes or rubble was laid on top of the tiles. In the more out of the way districts stones were used instead of tiles. Various systems of building stone drains were employed. In certain cases the bottom of the drain was paved or soled with flat stones, and the drain built with a rectangular "eye." In one drainage case in Caithness where flagstones were readily available the drain was built in the form of an inverted V. In all cases great care was taken in laying the pipes or stones. The outlets of the larger drains were frequently finished with stonework. Lateral drains were joined to leader drains in such a manner that the water from the former flushed the latter. In certain cases a good deal of levelling work had to be done before the scheme could be proceeded with.

The following notes, supplied by Mr A. Forbes regarding field drainage on the farm of Rettie, Banff, over a period of years, are of interest, and show the value of thorough draining:—"Field drainage is believed to have been begun on the farm of Rettie in the year 1825. The method then adopted was to dig tracks through 'wet spots' at a depth of from 18 inches to 2 feet, and fill in the tracks with pebbles from the sea beach or stones gathered off the land. This appears to have been the only method of land drainage until

tiles, or mugs, half-moon shaped, came into use. The mugs were laid in tracks about 2 feet deep, and put on strips of wood where the bottom of the drain was soft. This method was an improvement on the old stone drains, and it increased the productivity of the soil in such a marked degree that a large area of the farm was drained in that way. Its chief defects were that the drains were much too shallow, being in some cases not more than 18 inches deep, that the titles were too small, being only from 1 inch to 2 inches in diameter, and that no attempt had been made to drain the farm systematically.

"On my becoming tenant of the farm some twenty years ago, I at once began a systematic scheme to drain the land, which consists of all kinds of soil from a sandy loam to a heavy clay. The drains were cut to a depth of 3 feet 3 inches, with leaders 3 feet 6 inches, where there was sufficient fall to get that depth. They were placed 24 feet apart as a general rule, but when marking off a field for draining the width was altered a few feet either way, so as to take advantage of any hollow ground such as a 'mids.'

"The parallel system of field drainage was adopted in preference to the 'herring-bone' system. The small drains, laid out perpendicular to the slope, entered the leader drains, which are diagonal to the slope, from above, and at such an angle as to scour the leaders. This system I employed as being more economical and at least as efficient as the 'herring-bone' system. It also enabled me to have the minimum number of leader mouths. These I protected by building them up with stones, so as to keep all growth away. This method of drainage has proved very satisfactory, and has increased the productivity of the farm in a marked degree.

"The first field to be drained by me was one of thirty-two acres. It was then in second year's grass, and the grass was so poor that I began draining it at the height of the grazing season in the month of June. None of my neighbours had ever seen a decent crop on this field, and insisted that the land was not worth the cost of draining. The field was so wet that fully one-third was overgrown with rushes. Nevertheless, I drained the whole field, and it paid me to do so. A crop of oats, taken the first year after the field was drained, yielded 5 quarters per acre. The following year the field was laid down in turnips with a very moderate dressing of dung, namely, twelve loads to the acre, along with artificials at the rate of 6 cwt. per acre. The crop was all that could be desired. Since then the field has been cropped in regular rotation, and is now one of the best growing fields on the farm."

Hill Drainage.—Considerable advantage of the scheme was taken by sheep farmers to clean out sheep drains which had been allowed to remain untouched during the war, and to form new drains. In many cases the old drains were overgrown to such an extent that the work of cleaning them out was practically as

difficult as the excavation of a new drain. The advantages of hill drainage are briefly as follows :—

1. Sedges and other coarse plants are replaced by nourishing grasses.
2. Sheep are healthier, owing to the danger from liver fluke being minimised.
3. Fewer drowning accidents amongst sheep and lambs take place.
4. The movements of the sheep are less hampered, and drier beds are secured.

In the case of hill drainage only the surface water is got rid of, and the method employed is to cut out an open drain with well-sloped sides to a depth exceeding that of the turf, and ranging in depth from 6 inches in hard ground to 18 inches in flush (flow) land. Special tools are required. Thus a special sharp-edged spade is used for cutting the sides of the drains and slicing off suitably sized sods. Frequently the men work in pairs. The drain to be excavated is first of all lined out by cord. Each man then cuts his side down to the required depth. Thereafter the sods are sliced into suitable sizes, and the drain is excavated by the two men working together removing the sods with drags. As the work of dragging out the sods is very heavy, the advantage of two men working together is readily apparent. The sods thereafter are piled up, turf downwards, on the lower side of the drain, and at a distance of about a foot from the edge. Each sod as it is laid out overlaps part of the previous one. This jamming prevents the turf being displaced. The bottom and sides of the drain are thereafter trimmed, care being taken to remove all roots. Various points have to be noticed in carrying out the work. In laying out drains on steep slopes it is advisable to run them diagonally down the slope. This enables the surface water to be more easily caught, while at the same time the drains are less subject to erosion, undercutting and choking up in the flatter reaches. In cleaning out choked up drains it is most important that all roots be removed from the bottom of the drain. In old drains where undercutting has taken place the side must be pared off to a suitable angle, so as to minimise the danger of lambs or sheep falling in, or if they do fall in, to allow them an easy means of exit from the drain. A well-built-up wall of excavated sods is of great value for sheltering young lambs in severe weather. Where pot holes occur in old drains, these should not be filled up by tramping in sods, but the bottom of the drain immediately above and below the pot hole should be excavated so as to allow the water to flow on without interruption. In flush or flow land, drains may be placed at distances of 30 to 60 yards apart. One of the main secrets of successful drainage lies in the skilful planning of the drains. On well-managed sheep grazing it is customary to clear out a certain proportion of drains every year. On flat farms in the North of Scotland this proportion varies from one-fifth to one-seventh of the drains, the effective life of the drains on such

farms being considered to be from five to seven years. On hilly farms drains may last from fifteen to twenty years.

Paradoxical as it may seem, a sheep-grazing may be spoiled by over draining. Drainage has the effect of reducing the amount of such plants as cotton grass (draw moss), deer hair, spret, stool bent and pry (carnation grass), all of which are most important because of their ability to afford nourishment during the early spring months, when there is little or no grass.

The following information regarding hill drainage is supplied by a Berwickshire sheep farmer:—"When cutting new drains I would always lay them across the hill-side with only sufficient slope to give the necessary fall. My reasons for this are that in this way fewer drains suffice, they do not run so deep and less soil is thus carried down, while there is less danger of lambs being drowned, as the drains grow together, to some extent, at the top. I make the drains 18 inches deep, and from 20 to 24 inches wide at the top. In mossy and marshy land I would have them wider at the top, as they grow together more. I do not believe in having the drains more than 6 to 8 inches wide at the bottom, as, if the water covers the bottom, rushes are not so likely to grow.

"When there are springs on the hill-side, it is generally beneficial to irrigate any bent or lea heather further down with spring water. The water may be allowed to flood the bent for a year or longer, but when rushes begin to appear it should be diverted to fresh ground. This treatment rots the roots of the bent, and encourages finer grasses. It is an advantage if the water runs below the surface."

Repairs to Embankments and the Cleaning Out of Main Ditches.—The amount of work done under this heading was relatively small. The need for this class of drainage is far less evident in a hilly country like Scotland than in a flat country like England. Moreover, weather conditions in certain cases were unfavourable to the carrying out of this class of work. In the northern area schemes for repairing tidal embankments at the mouth of the Findhorn in Morayshire, and at the mouth of the Beauly River were successfully completed. In the latter case the embankment was pitched with stone from a local quarry, and four tidal valves were inserted.

Ensilage.

In connection with the brief article on this subject which appeared in the last issue of the *Journal*, the following notes have been supplied by an agriculturist in the Moray Firth area who has also had experience in making silage without a permanent building.

A pit silo can be made by digging into a dry bank in the face of rising ground. The size should be governed by the quantity of material available, but a suitable size is 30 feet long by 10 feet broad, and say from 8 to 10 feet deep at the back of the pit.

Preferably it should be lined with rough "backs," and the walls of the pit should have a slight "batter," so that the area of the pit is slightly less at the bottom than on the top. This allows the ensilage to settle compactly. One end is left open for carting in the material. The bottom of the pit should have a slight slope for drainage. To prevent wastage a layer of bracken or inferior straw should be put in the bottom of the stack or pit. The crop should be cut green and carted in. The carting helps to consolidate the silage. When about half full it should get two or three days to consolidate, and then be filled up. When it is filled, it should be covered with bracken or straw, and about 2 feet of earth put over it. It is important to see that the material is well packed about the sides so as to exclude air.

A trench silo can also be made on the top of rising ground, preferably where the soil and subsoil are dry. A length of 25 yards by 5 yards and say 4 feet deep will hold about 400 loads, and the ends of the trench should be inclined so as to allow carting in and out. In shape it would be somewhat like a manure heap, and the carting over it helps to consolidate it. It should be well arched with a slope say of one in three, which should be covered with bracken and earth, and a day or two given to allow it to consolidate during the filling. The sides can be treated as in the pit silo with "backs."

As to the crop, the mixture would largely depend on the nature of the soil. On good soil a mixture of tares and oats would be the best—one bushel tares and three bushels oats per acre, which should be cut for silage when just on the turn to ripening, when the heads are well filled and provide excellent feeding. From five to seven bushels of oats alone can be put in. We had one field which was light sandy soil, and in this we sowed a mixture of winter rye, winter wheat and winter tares. The crop was cut green one day with a mower and carted into the pit the next day, and during filling a horse was kept continually tramping the silage.

The height of the centre of the material of any pit or trench silo should be from 6 to 8 feet above the ground level so as to ensure a slope for drainage and to allow for settling. The wastage should be very slight: say 5 per cent., for practical purposes negligible, but this largely depends upon having the bottom and top covered with bracken or straw. If these are not available the wastage of course is more. Good packing also tends to eliminate wastage.

In from two to three months the silage is matured and ready for feeding. We cut it like hay and fed it to Highland and Galloway cattle outside at the rate of about 10 lb. per head per day. We have not tried it for inside feeding. We found it a great advantage to break up a few acres on the fringe of rough pasture, sow it out and make silage, and in this way provided keep for cattle that were never under cover in winter.

Recent Swedish Feeding Tests.

Green Fodder Ensilage: Its Composition, Fodder Value and Use.—During the last few years a series of investigations and feeding experiments has been carried out at the Department for Feeding Research of the Swedish Agricultural Experiment Station with regard to silage made from mixtures of green field peas, vetches, barley and oats. These investigations, summarised in Professor Hansson's report (No. 234, 1922), have shown:—

1. That green forage, as well as aftermath, well ensiled, is a good feed for milk cows. The best mixtures for the purpose contain 30 to 50 per cent. of leguminous plants, and the crop should be cut when the pods are well filled.

2. The best results are obtained when the green stuff is cut into short lengths and packed closely, so that air is excluded as completely as possible. If the forage is dry, water may be added to it because by this means air is kept out and the preservation is guided in the right direction. For the same purpose water may be added to the top of the mass in the silo.

3. The composition of the green forage ensilage is most suggestive of that of the green stuff from which it is derived. Its percentage of dry matter is higher because of the loss of water. In addition considerable changes have taken place in the composition of its crude protein and crude fat (ether extract).

A great part of the original protein changes into such cleavage products as peptones and amino-acids. These may have the same nutritive value as true proteid. Even with successful ensiling 10 to 20 per cent. of the total nitrogen compounds seem to be transformed to ammonia, which in no wise can supply the proteid requirements of animals.

In ensiling, considerable quantities of organic acids arise from sugar or other carbohydrates. These acids partly remain with the ether extract in an analysis and increase the quantity of this. They have a much lower nutritive value than true fat. The lowest percentage of free acids reached has been 1 per cent. The presence of foul-smelling butyric acid indicates that the ensilage has been unsuccessful.

4. Green fodder silage has a favourable influence on milk production: it has caused no change in the fat percentage in the milk.

5. Of well-ensiled aftermath 7·0 to 7·5 lb., and of green forage silage, containing 30 to 50 per cent. of legumes, 6·5 lb. constitutes a fodder unit. In either case the unit contains 1·75 to 1·8 lb. of dry matter. Silage composed principally of barley and oats has a lower food value.

6. About 33 to 44, or at most 55 lb. of green fodder silage can be given to cows per head daily, specially as a substitute for roots. Its high percentage of dry matter enables it partially to replace hay and straw, and its high proteid content enables it to save part of the concentrates rich in proteid. Well ensiled green fodder contains from three to five times more proteid per lb. than roots.

7. The silage has a favourable dietetic effect.

8. Milk from cows fed on ensilage is unsuitable for making cheese, especially that of the Emmenthal-Gruyère type, in which the curd is heated to a high temperature. In such cheeses a

fermentation takes place, attended by a strong development of gas.

Feeding Standards for Ewes.—During the earlier part of 1922 a feeding experiment with a score of pure-bred Shropshire ewes was carried out in Sweden in order to get data for estimating the food requirements of ewes while in lamb and in milk. The test lasted from January 20th to May 16th. The ewes averaged 156 lb. at the start, and a daily ration per head of 3½ lb. of hay (clover and grasses), 7½ to 5½ lb. swedes and ½ to 1½ lb. ground oats and barley was supplied. Most of the lambs were born in March, and the final result averaged 1¼ lambs. This, as well as the earlier Norwegian experiments of Saeland and Lalim, indicates that Kellner's feeding standard for breeding ewes must be modified. In the first place, the bare maintenance requirements of sheep are lower than Kellner suggested, with regard both to total food requirements and to proteid. On the other hand, these increase so much during gestation that this must be taken into consideration when feeding sheep in winter.

The Scandinavian and other experiments are summarised thus in Professor Hansson's report, No. 235:—

1. The bare maintenance requirements of sheep are satisfied by 1 fodder unit and ·055 lb. of digestible proteid per 100 lb. live-weight.

2. The food requirement of pregnant ewes at the beginning of winter is about 1·2 fodder units per 100 lb. live-weight, with about ·07 lb. of digestible proteid per unit.

3. The food requirements of pregnant ewes during both the last months of gestation is about 1·5 fodder units per 100 lb. live-weight, with ·085 lb. digestible proteid per unit.

4. Ewes in milk require about 2 units per 100 lb. live-weight, with ·1 lb. of digestible proteid per unit if they are to feed their lambs well without getting lean themselves. With this allowance the lambs may have some extra feed, specially after they are 1 to 1½ months old.

5. If ewes are in good condition at the end of the grazing season they may get a ration somewhat below the corresponding nutritional requirements without involving risk to their own development or that of their lambs.

6. Accordingly, the feeding standard would be:—

Per Day.	Per 100 lb. Live-Weight.		Lb. of Digestible Proteid per Unit.
	Fodder Units.	Digestible Proteid. Lb.	
Beginning of Winter Feeding .	1·0—1·2	·070—·084	·070
During Last Months of Pregnancy	1·3—1·5	·110—·128	·085
During Lactation	1·8—2·0	·180—·200	·100

Judgment must be exercised in using this standard, *e.g.*, the condition of the ewes at the beginning of winter must be taken into consideration.

Value of Coconut Cake, Coconut Meal and Linseed in the Feeding of Cows.—During the winter 1921–22 experiments were carried out in Sweden to determine the value of coconut cake, extracted coconut meal and ground linseed for dairy cows. The feeding experiments with the coconut feeds were conducted as group trials on two farms using forty-two cows. For the test 3·3 lb. of coconut cake or meal was replaced by 3·96 lb. of wheat bran and ·33 lb. of groundnut cake. With linseed only one test was made, a period test, in which 2·2 lb. of linseed was replaced by 2·2 lb. of ground oats and 2·2 lb. of bran. The results are summarised in Professor Hansson's report, No. 236, as follows:—

1. The coconut feeds are excellent for dairy cows, have a favourable dietetic effect and a favourable influence on milk production.
2. Coconut feeds increase the fat percentage in the milk.
3. Cakes with 7 to 8 per cent. of fat increase the butter fat in milk more than meals with 3 to 4 per cent. of fat.
4. This effect of the coconut feeds depends on the amount supplied daily to the cows, the length of time during which they are fed and on the other foods supplied along with them to the cows.
5. Of thirty cows getting coconut feeds, twenty-eight reacted in giving higher fat percentages in the milk, and one of the remaining two was in abnormal health.
6. Taking into consideration both the quality and quantity of milk yielded ·85 lb. of coconut cake would constitute a fodder unit.
7. Similarly, ·9 lb. of coconut meal is required to equal a fodder unit.
8. Ground linseed considerably increases both the fat percentage in the milk and the total fat production.
9. One lb. of normal linseed seems to be about equal in nutritive value to 1 lb. of ground oats + 1 lb. of wheat bran.
10. Ground linseed is much appreciated by the cows, has a good dietetic effect, and a favourable influence on the coat of hair.

The actual analyses of the coconut feeds used and their production values as found in the experiments are shown below. The close agreement in the food values established at the two different farms may be noted:—

	Fat.	Protein.	Carbo-hydrate.	Fibre.	Lb. per Unit.
Coconut Cake—					
Farm A . . .	7·24	19·63	38·65	16·29	·86
" B . . .	7·66	19·82	38·47	16·42	·82
Coconut Meal—					
Farm A . . .	2·97	20·50	45·67	12·71	·90
" B . . .	3·89	23·99	42·18	11·61	·87

Potato Diseases.

A QUESTIONNAIRE was issued to the Board's Inspectors engaged in the work of examination of potato crops in 1922, with a view to discovering the prevalence of disease in relation to the different varieties. The following is a summary of the information thus collected :—

Blight (*Phytophthora infestans*) was not widespread owing to the cold season, and comparatively little damage is likely to result from this disease this season. Blight was observed in the first fortnight of August in the early varieties, particularly on Witchhill and Katie Glover, and to a less extent on Duke of York. From the middle of August Arran Comrade was often severely affected, and British Queen was also badly attacked. Towards the end of August the disease was noted as severe on the following additional varieties, stated in order of severity :—King Edward, Great Scot, Abundance, Crusader, Majestic, Up-to-Date, Tinwald Perfection and Kerr's Pink : it was also observed on Ally and Arran Chief. The most resistant variety was Golden Wonder, while Arran Chief appeared to have a fair degree of resistance, and in some places the varieties Ally and Kerr's Pink were resistant.

Mosaic disease appeared to be widespread in all districts. The varieties most frequently and most severely affected were the Langworthy types, including Golden Wonder. Arran Chief was the next worst, with Tinwald Perfection about equal to it. Irish Chieftain was very severely attacked but, as the acreage was small, the number of recorded cases was less. Magnum Bonum, which occurred frequently as a rogue, was also severely affected. The frequency and intensity of the disease were much less marked on Kerr's Pink and Lochar, the varieties next in order. Rhoderick Dhu was noted a few times as being slightly affected, while two reports were received of President and Northern Star being badly diseased. One report of severe attack was received in respect of each of the following varieties :—Dargill Early, Fortyfold, Myatt's Ashleaf, Immune Ashleaf, Dunvegan, Catriona, Seedling 338(2) The disease was reported as occurring once on each of the following :—Champion, Gregor Cups, King Edward, Majestic, King George, Sharpe's Victor, Utility, America, General, Ally and British Queen.

The following varieties were frequently noted as being free or very resistant, and in no case was disease reported in respect of any of them :—Early Market, Great Scot, Abundance, Arran Comrade, Crusader. No mosaic was observed on any of the following, but they were only once noted as being free or resistant :—Sharpe's Express, Up-to-Date, Epicure and Templar. Ally was frequently noted as being free, but, as shown above, one report of disease was received.

Leaf Roll.—According to the observations reported leaf roll was not nearly so prevalent in Scotland as mosaic. Every one of the thirty-one replies received indicated the presence of mosaic, while only fifteen indicated leaf roll, the other sixteen stating that

leaf roll was not observed or was very slight. The two most severely affected varieties were Lochar and Kerr's Pink (twelve reports). British Queen (nine reports) follows closely, while President, Majestic, King Edward, Duke of York and Crusader (three reports) were affected, but to a much less extent. The disease was also observed (two reports) on King George, Witchhill, Great Scot, Arran Chief, Abundance, Sharpe's Express, Up-to-Date, Irish Chieftain, Rhoderick Dhu, Golden Wonder and Katie Glover. There is one report of its occurrence on each of the following:—Dargill Early, Immune Ashleaf, Tinwald Perfection, Magnum Bonum, Evergood, Arran Comrade and Bishop.

No report was received of any variety being immune.

Blackleg was reported from practically all districts, and was observed on most varieties, though some varieties were much more severely affected than others. The extent of the infection of a variety may be due partly to varietal characteristics, or partly to the conditions under which the stocks have been accumulated. While, therefore, the order of the observed degree of infection of the common varieties is given, it must not be deduced from the figures that, if the varieties were grown under similar infective conditions, they would be susceptible in the order given. This remark, indeed, applies more or less to the other diseases which are carried on from year to year by the seed tubers.

The variety most severely affected with blackleg was Kerr's Pink: the next was Great Scot, and the next British Queen. Decidedly less severely, but still badly affected, were Majestic and Eclipse, with Rhoderick Dhu coming next. Reports were received of the occurrence of the disease on King Edward, Arran Comrade, Abundance, Crusader, Lochar, President, Up-to-Date, Witchhill, Duke of York, Tinwald Perfection, Great Scot, America, Golden Wonder and Field Marshal.

One or two reports stated that all varieties seemed susceptible, while another report gave Ally the credit of being free.

Corky scab was twice reported as occurring in crops of Great Scot. This disease has been noted elsewhere as being very prevalent this year as an effect of the wet season.

Rhizoctonia solani appeared to be worse in the West, and to have no preference for any particular varieties. Cases were reported of the disease being very severe on Epicure, causing much blanking and serious loss of crop. One report stated that the disease was rather severe on low-lying heavily manured ground.

Sclerotinia was not often observed, and the only varieties on which it was reported to occur were King Edward and Crusader.

Botrytis was severe on the large plots of Kerr's Pink at East Craigs, causing the plants to die down prematurely. No other report of its occurrence was received.

Rust was frequently observed on Kerr's Pink, causing a browning of the leaves and premature withering. In one case the field was high-lying and of a light sandy nature. In another

case rust was observed on a crop grown in an impoverished field where the surface soil was mixed with raw clay sub-soil. Rust was also reported twice as occurring on Tinwald Perfection, and once as occurring on Arran Comrade.

Little Potato.—This is the name used to designate the condition, the symptoms of which are that the seed tuber fails to produce a shaw, and instead produces a number of small tubers borne on short stolons growing out from the eyes. This condition was very seldom observed. Two reports stated that it was found chiefly with early varieties (in one case Duke of York in particular), but another report recorded its occurrence in Golden Wonder, Tinwald Perfection, Lochar, King Edward and Kerr's Pink.

No information was received with reference to the origin of the seed of affected stocks. One opinion is that the trouble is due to using seed tubers which had ripened too quickly the previous season and had become over-ripe. In this connection it is known that if tubers are kept over into the following summer and autumn in a dark store or cellar and left uncovered, some of the tubers may develop the symptoms of little potato. The small tubers so formed are considered to possess a fine flavour and texture after boiling.

Second growth was, in marked contradistinction to last year, not common. It was observed by one inspector as occurring on early varieties, particularly King George, which had been left in the soil after maturity.

Splitting of the tubers—a form of second growth—was noted in a crop of Great Scot, an unusual occurrence in this variety.

Supertuberation was stated in one report to occur frequently on America, also on Eclipse and Epicure in sandy soil.

Seed Improvement.

THE following account of the commercial production of seed according to the Swedish method and the progress already made in this direction in Canada and New South Wales is taken from the *International Review of the Science and Practice of Agriculture*, which refers to articles by E. Breakwell in the *Agricultural Gazette of New South Wales*, and by R. H. Newman and G. H. Cutler in the *Agricultural Gazette of Canada*:—The improvement of cultivated plants and the commercial production of seed therefrom have been for some time vigorously undertaken by European countries, and also by America. The methods adopted in Sweden have served as a model for other nations, so that an account of the methods employed in that country is of general interest.

SWEDEN.—The General Swedish Seed Company, a private commercial body for growing, treating and selling farm seeds in bulk, buys all the improved seed from the Swedish Institute at Svalöf for further commercial production, which is carried out

partly on its own land, and partly through contracts with private growers. The terms of contract are briefly as follows:—

(1) The grower undertakes to grow the seed for the General Swedish Seed Company; (2) the grower is bound to deliver to the seed company without remuneration the same weight quantity as received with an addition of 25 per cent.; (3) the grower is bound to deliver the entire balance of the crop to the seed company for a fixed remuneration; (4) should the company be unable to accept the average quality sample which the grower is bound to send to the company, the grower's obligation shall cease; (5) the grower shall deliver the crop in clean condition; (6) the grower binds himself to allow the seed company's representative to inspect at any time, and at the company's expense, the growing crop at any place; (7) should the crop not be approved for seed by the seed company on account of faulty harvesting, bad smell, low germination, mixing with foreign sorts, disease or other causes, and providing this is caused in any way by neglect or improper handling by the grower, he shall be bound, if so claimed, to pay for the seed he received at the price quoted for the goods in question in the year's catalogue; (8) should the goods delivered be found not up to sample, or should they show, upon closer examination, that they do not reach the standard mark on the measure, and the goods thus be in any case unfit for seed, they will then be valued according to the mutual agreement of the grower and the seed company.

CANADA.—It seems practically certain that this method served as a model for Canada. A Canadian Seed Growers' Association was founded in 1900.

The Association appoints provincial officers for field inspections, and its own officers for the final inspection in the sack. The method adopted is as follows:—

(1) Membership is open and free to any *bona fide* farmer who has shown himself capable of producing improved pure seed; (2) the farmer who undertakes to grow pure seed obtains his foundation stock from the Association. Such seed is either "first generation registered seed" (*i.e.*, F_1, F_2, or F_3 progeny of an improved selected strain) or *élite stock seed* (*i.e.*, pure stock of seed originating from a single plant, or obtained from a hand selected seed plot); (3) any seed of any kind of crop produced or selected by a member during the succeeding years is entitled to registration by the Association; (4) certificates are given: (*a*) for seed grown according to regulations and recovered from élite stock seed, such seed being marked *registered seed* and (*b*) for pure élite stock seed; (5) no certificates are issued unless the seed be (*a*) pure as to variety and true to type; (*b*) free from seeds of other cultivated plants; (*c*) free from seeds of weeds coming within the meaning of the term "noxious weeds" as applied to the Seed Control Act; (*d*) free from or containing not more than one seed of other weeds per lb. of cereals or per oz. of smaller seed; (*e*) well-matured, clean, sound, plump, of good size and colour and free from disease; (*f*) up to the percentage standard of vitality recognised for good seed of the kind under the Seed Control Act.

The methods thus outlined are extremely successful and are

well supported, and at present the demand for "registered seed" is greater than the supply. For example, the Canadian Seed Growers' Association is endeavouring to assemble in Ontario a number of carloads of registered Banner oats, but the supply to meet the ordinary demands of the trade is inadequate. The author considers that at least one good seed-producing centre should be established in each district where high-class seed of the kind most in demand may be produced to a high degree of perfection and in considerable quantity.

Professor Cutler states that during the past three years the Department of Field Husbandry of the University of Alberta has been putting forth every effort to standardise and purify old varieties and breed new varieties of the different farm crops. During that time there has been an insistent and steady demand for pure seed representing suitable varieties, and for information as to how "registered seed" can be obtained or produced. In answer to these applications, samples have in nearly every case been sent out; the size varying from a few ounces for testing to 3 bushels or more for multiplication. During the past two seasons over 1500 samples of seeds were placed in the hands of interested seed growers who are undertaking to test and multiply given improved and purified strains of the different farm crops. This is the beginning of a very important movement in seed production in Alberta, but necessitates special organisation. In meeting adequately, therefore, the needs of the farmers' demands, the University of Edmonton is prepared to co-ordinate all co-operative seed testing, seed distribution, and multiplication work under one organisation to be known as the "Alberta Crop Improvement Association."

NEW SOUTH WALES.—The Department of Agriculture has already taken the initial steps for the production of better seed. The method adopted differs from those in Canada and Sweden in the fact that the Department deals directly with the farmers. It is interesting to note that a list of growers of pure seed of good quality of wheat, oats, maize, sorghum, Sudan grass, potatoes and other crops is published in the *Agricultural Gazette of New South Wales* monthly, in order to enable farmers to get into direct touch with reliable sources of supply of such seeds. The list is compiled after inspection of the seed and report by a field officer (preferably during the growth of the crop), and farmers who have pure high-class seed of good quality of any variety of farm crop are invited to communicate with the Department of Agriculture, Sydney.

Agricultural Labour in England During the War.

THE International Institute of Agriculture have issued a paper by Mr J. K. Montgomery, entitled "The Maintenance of the Agricultural Labour Supply in England and Wales during the War." It contains a study of the measures taken during the war in England and Wales, not only to prevent the supply of agricultural labour being depleted by enlistment, but to provide labour for the increased cultivation

required to assure the food supply of the country. The arrangements made for the retention of certain classes of agricultural labourers on the land by exempting them from military service or by delaying their call to the colours are fully described, as also are the steps taken for the detachment of soldiers from military duties for work on the land, for the employment of prisoners of war and interned civilians, and for the training and employment on a large scale of women landworkers, as well as the various other measures adopted for replacing the mobilised labourer and supplying additional labour. A measure of different type was the fixing of minimum wages for agricultural labour, one of the objects of which was to induce the agricultural labourer to stay on the land by ensuring to him wages commensurate with the cost of living; a very full statement is given both of the methods of fixing minimum wages and of the wages actually fixed. Copies of this publication may be obtained from the Ministry of Agriculture and Fisheries, Whitehall Place, London, S.W. 1, price 2s. 6d.

Agricultural Returns for Scotland, 1922.

THE Abstract of the Agricultural Returns, printed on pp 129–136, shows that the total area under all crops and grass amounts to 4,725,499 acres, a decrease of 4105 acres as compared with 1921, the arable land having decreased by 10,999 acres, while the area under permanent grass is greater by 6894 acres. The land under rye-grass and other rotation grasses and clover has increased by 34,388 acres; the decrease in the area under other crops is thus 45,387 acres. The area under wheat shows little change, while that under barley has decreased by 13,701 acres, or 8 per cent., and that under oats by 23,223 acres or 2·3 per cent. The total area under the cereal crops is 1,218,393 acres, or 36,039 acres less than last year. Beans show a decrease of 1012 acres, or 21·5 per cent. Potatoes have increased by 3584 acres, or 2·3 per cent., while the area under turnips and swedes is less by 6677 acres, or 1·6 per cent. The area under flax has decreased by 162 acres, the acreage being 290 compared with 452 last year. Rape shows a decrease of 5585 acres, or 33·4 per cent., while the acreage under vetches, tares, etc., for fodder is less by 502 acres, or 5 per cent. All the other crops show increases. The increase in the area under rotation grasses and clover is 34,388 acres, or 2·3 per cent., the area for hay being greater by 21,045 acres, and that for pasture by 13,343 acres. The area under permanent grass is greater by 6894 acres, or 0·5 per cent., the area for hay showing an increase of 1840 acres, and that for pasture of 5054 acres. The total area cut for hay was 576,405 acres, or 22,885 acres more than last year.

The area under wheat, barley, oats and potatoes this year is, in round figures, 1,368,000 acres; this is 33,000 acres less than last year, but 15,000 acres more than in 1916, which was the basal year for the food production campaign.

The live stock returns show that the numbers of cattle, sheep and pigs have increased, while horses have decreased. Horses used for agricultural purposes are more numerous by 194, while unbroken horses have decreased by 3356; the decrease is almost

wholly accounted for by those under one year, which show a diminution of over 20 per cent. As "other horses" are fewer by 1690, the net decrease thus amounts to 4852, or 2·2 per cent. Cows in milk have increased by 12,448, or 3·6 per cent., and cows in calf by 2971, or 7·1 per cent.; while heifers in calf have decreased by 6236, or 11·4 per cent. The total number of breeding and milking cattle has thus increased by 9183. Bulls used for service have decreased by 77. Other cattle of two years and above have decreased by 28,931, or 12·7 per cent., while those of one year and under two show an increase of 17,895, or 7·7 per cent., and those under one year of 5602, or 2·5 per cent. The total number of cattle has thus increased by 3672, or 0·3 per cent. Sheep are also more numerous than in 1921, the total number showing an increase of 25,586, or 0·4 per cent. Breeding ewes have increased by 57,717, or 2 per cent., and lambs by 26,272, or 1 per cent., while rams have decreased by 307, or 0·4 per cent., and other sheep of one year and above by 58,096, or 5·6 per cent. All classes of pigs have increased in number, sows kept for breeding by 445, or 2·5 per cent., boars used for service by 224, or 11·6 per cent., and other pigs by 4717, or 3·8 per cent. The total increase in the number of pigs amounts to 5386, or 3·7 per cent.

The returns collected this year include, as in 1921, statistics of the acreage owned by the occupiers of the holdings and particulars relating to labour and poultry. None of these figures is included in the printed abstract.

The total area of land under crops and grass owned by occupiers of holdings this year amounts to 820,749 acres, as compared with 756,663 acres in 1921, showing an increase of 64,086 acres.

Labour employed on holdings (exclusive of the occupiers, their wives and domestic servants) totalled 124,616, as compared with 126,898 last year, a decrease of 2282, or 1·8 per cent. Of these 102,336 were returned as regular workers and 22,280 as casual workers. Regular workers comprised 81,524 males and 20,812 women and girls, while casual workers were made up of 11,181 males and 11,099 women and girls.

The poultry figures are as follows:—

Fowls hatched before 1922 - - - -	2,183,042
Fowls hatched this year - - - -	2,092,726
Ducks hatched before 1922 - - -	138,928
Ducks hatched this year - - -	103,789
Geese hatched before 1922 - - -	6,262
Geese hatched this year - - - -	15,756
Turkeys hatched before 1922 - - -	14,228
Turkeys hatched this year - - -	52,773

Annual Estimates of the Produce of Crops. The following statement regarding the produce of crops for 1922 was issued on 11th December.

The sowing of wheat was carried out under favourable conditions. The crop brairded well, but was checked later owing to frost and snow. Growth was unusually slow during the spring months, and while better progress was recorded in June the

unsettled weather in July and August delayed the ripening of the grain, and harvest was much later than usual. Only a small proportion of the crop was secured by the end of September, and

Preliminary Statement showing the ESTIMATED TOTAL PRODUCE and YIELD PER ACRE of Wheat, Barley, Oats, Beans, Hay, Potatoes and Roots in SCOTLAND in the Year 1922, with COMPARISONS for 1921, and the AVERAGE YIELD PER ACRE of the Ten Years 1912-1921.

Crops	Estimated Total Produce		Acreage		Average Estimated Yield per Acre		Average of the Ten Years 1912-1921
	1922	1921	1922	1921	1922	1921	
	Quarters	*Quarters*	*Acres*	*Acres*	*Bushels*	*Bushels*	*Bushels*
Wheat	315,000	321,000	65,251	65,191	38·6	39·4	39·3
Barley (including Bere) .	736,000	739,000	157,020	170,716	37·5	34·6	35·4
Oats	4,812,000	4,793,000	988,392	1,011,615	38·9	37·9	39·3
Beans	16,000	18,700	3,692	4,704	34·6	31·7	36·7
	Tons	*Tons*			*Cwt.*	*Cwt.*	*Cwt.*
Hay from Rotation Grass .	679,000	581,000	431,601	410,556	31·5	28·3	30·7
Hay from Permanent Grass .	132,000	118,000	101,778	100,253	26·0	23·6	30·4
Hay from Timothy Meadows	91,000	87,000	43,026	42,711	42·5	40·8	
					Tons	*Tons*	*Tons*
Potatoes	1,192,000	1,040,000	157,404	153,820	7·6	6·8	6·5
Turnips and Swedes . .	6,880,000	7,132,000	404,112	410,789	17·0	17·4	16·6
Mangolds	34,500	35,500	2,008	1,771	17·2	20·0	19·5

in the majority of the districts the harvest was not completed until the latter part of October. The crop has, however, proved to be much better than was at one time anticipated, and the yield of straw is satisfactory in most cases. Barley and oats were sown in

fair order, but, as in the case of wheat, progress was slow and harvest was late and unusually protracted.

The planting of potatoes was carried out under excellent conditions, and was completed before the end of May. The sowing of roots was well advanced at that period, and was finished early in June. Potatoes generally were free from disease, and the yield proved to be heavy. Turnips and swedes were a fair crop, but mangolds yielded below the normal.

The total produce of wheat, amounting to 315,000 quarters, is less than that of last year by 6000 quarters, or 1·9 per cent.; the area under the crop is higher by 60 acres, but the yield per acre, 38·6 bushels, is 0·8 bushel lower than that of last year and 0·7 bushel below the decennial average. Barley, with a total produce of 736,000 quarters, shows a decrease of 3000 quarters, or 0·4 per cent.; the area under the crop is less by 13,696 acres, while the yield per acre, 37·5 bushels, is 2·9 bushels greater than last year and 2·1 bushels above the ten years' average. The total produce of oats, 4,812,000 quarters, shows an increase of 19,000 quarters, or 0·4 per cent. The area under the crop shows a diminution of 23,223 acres; the yield per acre, 38·9 bushels, is 1 bushel higher than last year, but 0·4 bushel below the decennial average. Beans show a decrease in total produce of 2700 quarters; the area under the crop is less by 1012 acres, and is the lowest on record. The yield per acre, 34·6 bushels, is 2·9 bushels higher than in 1921, but is below the decennial average by 2·1 bushels.

The total produce of hay, taking all kinds together, is 902,000 tons, which is greater than that of last year by 116,000 tons, or 14·8 per cent. Hay from rotation grass shows a total produce of 679,000 tons, an increase of 98,000 tons, or 16·9 per cent. The area is greater by 21,045 acres, and the yield per acre, 31·5 cwt., by 3·2 cwt. Of the other hay, the total produce of which amounts to 223,000 tons, the ordinary meadows yielded 132,000 tons, and the timothy meadows 91,000 tons; the former, with an increase in area of 1525 acres, shows a yield per acre 2·4 cwt. above that of last year, while the latter, with an increase of 315 acres in area, shows a yield higher by 1·7 cwt. The average yield of the two together, which is not shown in the Table, is 30·9 cwt., or 0·5 cwt. above the decennial average.

The total produce of potatoes is estimated at 1,192,000 tons, which is 152,000 tons greater than last year's crop, and, with the exception of 1920, is the highest on record. The area under the crop shows an increase of 3584 acres, while the yield, 7·6 tons per acre, is 0·8 ton higher than in 1921; the yield per acre is equal to the record yield of 1920, and is 1·1 ton above the decennial average. Turnips and swedes show a decrease of 252,000 tons, the total being 6,880,000 tons. The area under the crop is less than last year by 6677 acres; the yield per acre, 17 tons, is 0·4 ton lower than in 1921, but is slightly higher than the decennial average. Mangolds, with a total produce of 34,500 tons, show a decrease of 1000 tons; the area is greater by 237 acres, but the yield per acre, 17·2 tons, is lower than last year by 2·8 tons, and is below the decennial average by 2·3 tons.

Acreage under each Variety of Potatoes in 1922.

A STATEMENT is printed at page 128 showing the acreage under each variety of potatoes in Scotland in 1922 as returned by growers of 1 acre and over.

As regards First Earlies it will be observed that Epicure easily holds the first place. The acreage under this variety comprises over 62 per cent. of the total area under First Earlies.

Of the Second Earlies Great Scot accounts for over 45 per cent. of the total area; the acreage has diminished to some extent as compared with 1921, but this variety still holds first place. British Queen has increased in area by over 200 acres, and now occupies second place instead of Arran Comrade, the area under the latter being diminished by almost 1700 acres.

Among the maincrops Arran Chief is again first, the acreage under this variety being 30 per cent. of the total area. The variety King Edward VII. has increased in area by over 6000 acres, and comprises about 20 per cent. of the total. The area under Kerr's Pink is less by nearly 500 acres, but this variety still holds the third place.

Agricultural Conditions.

THE weather during September was, to a great extent, unfavourable for harvest work. During the early part of the month good progress was made in Kincardine, Forfar and Perth with the cutting and ingathering of the cereal crops, but rain and heavy mists later interrupted operations. In the north-eastern counties, Orkney, Shetland, and the western islands the ripening of the grain crops was slow and irregular owing to the cold and wet conditions, and in some districts the crops were badly laid. Elsewhere harvesting was more or less retarded on account of the broken weather. During the latter part of October cold and dry weather prevailed in the eastern, western and south-western counties, and this enabled late-cut crops to be stacked in good order. In the Lothians and Peebles the month was mostly suitable for harvest work and potato-lifting, but in Berwick and Roxburgh operations were interrupted owing to rain and fog. The securing of the grain crops was very protracted in the northern and north-eastern counties; heating in the stack was prevalent, and the quality of the grain in many cases is reported to be below the normal. Mild and unusually dry weather prevailed throughout the greater part of Scotland during November, and seasonal work of every description progressed satisfactorily. In Caithness, however, the month was cold and wet, while in North-East Banff and most parts of Aberdeen some snow fell during the first week.

The cutting of wheat began in a few districts in August, but only a small proportion of the crop was secured by the end of September; in the majority of cases the harvest was not completed until the latter part of October. The quality of the grain varies from fair to good, and, generally speaking, the results are

better than were at one time expected. The harvesting of barley was also more protracted than usual, and was not quite completed at the end of October. The grain is reported to be of inferior quality in South-West and Central Aberdeen and Central Perth, but elsewhere the reports are very similar to those regarding wheat. The harvesting of the oat crop was unusually slow and difficult. In some cases the crop was secured during the latter half of October, but in the northern and north-eastern counties, Orkney and Shetland, and the later areas of the south-eastern districts harvest was not completed until about the middle of November. In South-East Lanark and Islay the quality and condition of the grain are excellent, but, taking the country as a whole, the reports are very varied. The crop is of fair quality in the northern counties and the western islands, but in the north-eastern districts much of the grain is soft and discoloured, and the quality varies from fair to indifferent.

The lifting of potatoes was finished or practically finished in many districts by the end of October. Owing to the lateness of the cereal harvest this work was only begun at the end of October in Moray, most parts of Aberdeen, Roxburgh, Orkney, Shetland, Lewis and Skye, but the mild and dry conditions during November enabled lifting to proceed uninterruptedly. The crop is generally sound; some disease is reported in Forfar, but elsewhere it is not prevalent to any extent.

The lifting of turnips and swedes was completed or well advanced in several districts at the end of November, but in some cases they are only lifted as required. The condition and quality of the crop are generally satisfactory; in some parts of South-East Perth, however, the roots show signs of rot, while "finger-and-toe" is present in North-East Banff, Berwick, Caithness and South Ayr. Mangolds are generally free from disease, but in some cases the bulbs are small and of rather inferior quality.

"Seeds" grass is almost everywhere reported to be vigorous and healthy; clover is stated to be abundant in Forfar, Perth, the Lothians, Peebles and Ross.

The weather during November was very favourable for outdoor work, and good progress was made with autumn cultivation. Ploughing is rather backward in many districts, stubble ploughing being especially in arrears owing to the lateness of the harvest. Wheat-sowing was completed, or practically completed, in many districts at the end of November, and in all cases the seed was sown in good order.

Feeding cattle are generally in good condition, and have thriven well. Winter keep is ample everywhere except in North-East Aberdeen and North-East and South-East Perth, where the supply of turnips is rather short. Dairy cows have also done well, but in Wigtown they are stated to be leaner than usual at this period of the year. The milk yield has been fairly well maintained. Sheep have made satisfactory progress, and pastures have kept fresh and green.

The supply of regular and casual labour is adequate generally, and in many districts is more or less in excess of the present demand. In Stirling, Renfrew and Central Perth the supply of women workers is unequal to the demand, while in the last named district and in North-West Aberdeen domestic servants are rather scarce.

RECENT PERIODICAL LITERATURE.

The majority of the following extracts and summaries are taken from recent bulletins of the International Institute of Agriculture. Full references to the bulletins, and to the original publications quoted therein, may be obtained on application to the Secretary, Board of Agriculture for Scotland, York Buildings, Edinburgh.

Decree of the French Minister of Agriculture Respecting Enterprises for Mechanical Ploughing. *Journal Officiel de la République Française. Article* 1.—Contractors who undertake mechanical ploughing for others and are using more than two machines, or sets of total power of at least 200 H.P., may receive assistance from the State.

Should the petitioner be at the same time a threshing contractor, the H.P. required by the threshing apparatus may be deducted from the minimum H.P. prescribed for mechanical ploughing apparatus or sets, provided that the total power of the said mechanical ploughing apparatus or sets is not below 100 H.P.

In exceptional cases machines for use in viticultural, horticultural and kitchen-garden work shall be permitted to represent a total not exceeding 100 H.P., but they shall not be less than ten in number.

Article 3.—The assistance given by the State consists of premiums calculated on the basis indicated by the decree of March 31, and includes the additional premium provided for co-operative societies. The premiums are only for the mechanical ploughing apparatus or sets, threshing plants being excluded. These premiums are placed at the disposal of the interested parties in the following manner :—

(*a*) One half at the date when the demand is approved.

(*b*) The remainder in amounts of ¼ at a time, at the end of each of the first two agricultural seasons, and on production of the proofs required by Article 4.

In case of accident the beneficiaries shall be required to replace the destroyed apparatus or sets, and shall request, in the case of new purchases, a premium, the amount of which shall be fixed after taking into account the sums already paid by the State and the amount of insurance money already received.

Article 4.—The proofs of the areas to be ploughed shall consist in the production of the summary and detailed statement for the Commune showing the extent of the arable land, and giving the names of the farmer working them, and the sums paid by the latter for the work performed. These said statements, after having been certified as correct by the Mayors, shall be sent every year not later than August 15 to the Directors of the Agricultural Services of the one or more Departments where the work is being done, who, after due verification as required, shall forward the said documents, with their remarks, to the Minister of Agriculture.

Article 5.—Should one of the conditions of the agreement not have been fulfilled at the end of the first season, or should an incorrect return knowingly have been made, the half of the premium already paid shall be refunded to the Treasury by order of the Minister of Agriculture.

If one of the above-mentioned conditions remains unfulfilled at the end of the following seasons, the portion of the premium corresponding to the sum mentioned in par. (*b*) of Art. 3 shall not be paid.

Article 6.—Farmers who desire to benefit from the premiums provided in the present Decree must submit to all the measures of control and verification prescribed by the Minister of Agriculture.

Experiments in Treating Wheat Grain by Immersion in Nutrient Solutions in Italy. *G. D'Ippolito, Le Stazioni Sperimentali Agrarie Italiane.*—Experiments in treating wheat grain with solutions of different salts at varying degrees of concentration: some of the solutions used are known for their power as fertilizers and their effect as stimulants.

The results of the preliminary laboratory experiments do not justfy any conclusions as to the good effect to be obtained from fertilising seed by immersing it in nutrient solutions, for not only did both the nitrates and phosphates fail to produce any noticeable improvement, but the nitrates, after a certain point, proved distinctly injurious. Sulphate of potassium, however, though its fertilising power is inferior to that of the phosphates and nitrates, appears to have been of some advantage.

Sulphate of manganese, on the other hand, and to some extent ordinary water, were very beneficial.

As the open air experiments proved quite satisfactory it may be supposed that the advantages accruing from the immersion of seeds in ordinary water may be due to some special stimulating effect exerted by the latter on cellular activity, manifesting itself later in the stronger development of the root system, and consequently of the whole seedling.

Further, the negative results obtained by treatments with phosphates and nitrates disprove the hypothesis that the fertilising substances penetrating by absorption into the seed can afterwards affect the plant at a more advanced stage of growth. It would indeed be impossible to explain why the seedling does not at once use the nutrient elements at its disposal during the period when it most requires them.

The field experiments finally dispelled all doubts on the subject, for the plants that continued developing with greatest vigour throughout the entire period of growth, and hence gave the best yield, were precisely those that had shown their superiority from the earliest period.

Another important fact was demonstrated by the field experiments, viz., that even allowing for the experimental errors always accompanying such tests, it was clear that the plots yielding the finest crops were those sown with wheat treated with sulphate of manganese. Since it cannot be supposed that the manganese had a fertilising effect, owing to the small proportions (3 in 1000) in which it was used, it is most probable that it acted as a stimulant. Thus support is given to the new theory put forward by many investigators engaged in the study of the question, namely, that manganese plays the part of an active oxidising agent, not only directly but also indirectly transporting oxygen and fixing it in the soil.

In any case the results obtained naturally cannot be regarded as final, and it willl be necessary to repeat the experiments under more favourable cultural conditions in the hope of reaching definite conclusions.

Copper, the Active Principle in Sprays. *Fonzes-Diacon, Le Progrès Agricole et Viticole.*—Villedieu believed that his laboratory experiments with basic copper mixtures furnished sufficient proof of the non-toxic action of the copper, and therefore concluded that the anticryptogamic effect of these compounds must be due solely to the basic character of the medium.

He, therefore, advised that the usual mixtures should be replaced by a compound containing a large amount of lime, and hence very basic, in which the secondary part of fixative on the vine shoots should not be sulphate of copper, an expensive foreign product, but sulphate of aluminium, which can easily be supplied at lower cost by French industry.

Villedieu now fully recognises the complete failure of his formula, which was tested by experiments carried out in vineyards in various districts of France, but in his recent communication to the Académie des Sciences he is still of opinion that the efficacy of alkaline cupric mixtures in the control of

"mildew" is to be attributed to their basic character, and not to the action of the copper compounds.

The author considered that the toxic effect of the copper in these sprays was clearly demonstrated by Manceau's comparative experiments with alkaline, Bordeaux mixture and Villedieu's mixture. From these trials made in the open vineyard Manceau draws the following conclusions:—"Although the 1921 outbreak of 'mildew' was not severe, Viliedieu's mixture proved of little use, but the application of Bordeaux mixture kept the leaves healthy and insured a vigorous growth."

A convincing proof was obtained in the course of these experiments by adding 100 gm. of copper sulphate to a Villedieu mixture containing 5 kg. of lime, for the anticryptogamic action of the compound was found to persist throughout the whole vegetative period.

It is necessary, in order to realise the full significance of this experiment, to explain that the addition of so small a proportion of copper sulphate in no way altered the basic character of the mixture. In fact a little of the excess lime went to form a sulphate, thus setting free an equivalent amount of copper hydrate of the same basicity, and yet although the caustic property of the mixture was lessened, since copper hydrate is much less soluble than lime, it was still efficacious against "mildew."

Thus by the addition of a little copper sulphate, which was not sufficient to alter the basic character of the mixture, the vanished anticryptogamic action reappeared; is it due to the basic function that has not been changed, or to the copper? The author thinks there remains no shadow of doubt that copper compounds actually possess the efficacy against "mildew" that has been attributed to them as a result of long practical experience.

Pests of Stored Grain. *E. A. Back and R. J. Cotton, U.S. Dept. Agr. Farmers' Bulletin, 1260.*—In a comprehensive and well-illustrated pamphlet the authors discuss the occurrence of insects and mites amongst stored grain and methods for preventing infestation and destroying the pests. A summary of the contents of the pamphlet states that most of the damage done by insects to grain in storage and shipments is due to four species the distribution of which is world wide—the granary weevil, the rice or black weevil, the lesser grain weevil and the Angoumois grain moth. Others of the forty species or groups of species described in the bulletin can cause great damage to grain if storage conditions are unusually favourable for their increase. These four pests spend their larval life entirely within the kernel, where they live mostly unsuspected, and where they cannot be reached by the ordinary methods employed in grain-cleaning operations, such as fanning and screening.

The other pests are almost all surface feeders, most of their larvæ being found feeding upon broken grains. These move freely in the bulk of the grain, and may largely be got rid of by fanning and screening.

The most satisfactory means of destroying all stages of the grain pests are (1) maintaining the bulk of grain at a temperature of 120° to 130° F. for a short time, which does not destroy the germinating capacity of the grain; and (2) fumigating by means of carbon disulphide, carbon tetrachloride or hydrocyanic-acid gas, the first being the best for treating grain in bulk.

The Effects of Liming on the Availability of Soil Potassium, Phosphorus and Sulphur. *J. K. Plummer, Jour. of the Amer. Soc. of Agron.*—A discussion dealing with the important question of the effects of liming on the availability of soil potassium, phosphate and sulphur.

The more recent research, embodying laboratory extractions with weak solvents, pot studies using a variety of plants as indicators of the concentration of the soil solution in potassium and the analyses of their ash, lysimeter experiments by which the production of potassium has been measured, and field tests, has failed to show that basic compounds of calcium and magnesium increase, by chemical action, to any practical extent, the availability of the soil store of native potassium.

More research needs to be carried out before we can say that additions of

lime will reduce the necessity of applying soluble phosphates to the soil. As measured by yields, phosphates of iron and aluminium seem to be as available as calcium phosphates. It is very probably true that fixation of phosphatic fertilisers by colloidal absorption induced by iron and aluminium oxides is responsible for the failure of some crops to respond to phosphorus additions. Additions of lime to such soils undoubtedly flocculate some of these colloids, thus giving the soils a better physical condition for plant growth. Additions of lime before or after applications of soluble phosphates have greatly increased the efficiency of the phosphatic fertiliser. When insoluble calcium phosphate has been applied, it seems that applications of lime have reduced the effectiveness of the phosphate in the majority of cases.

The scant data of lysimeter experiments which deal with the question of sulphate availability or conservation, seem to show that liming with small amounts of lime, both small and large amounts of magnesia, magnesium carbonate, limestone, dolomite and magnesite, increases the solubility of native soil sulphate. Heavy applications of lime for a few years at least, apparently reduce this loss of sulphur from the soil.

Experiments with Manganese Compounds as Fertilisers in Italy. *A. Cauda, Il Coltivatore.*—The idea of using manganese dioxide as a fertiliser originated in the frequent need experienced by plants of finding oxygen at their disposal when growing on badly aerated soil, or at seasons when it is difficult to work the ground, and especially when it is a question of replenishing the lower strata of the soil with substances that easily yield free oxygen. Numerous successful experiments were made in digging in manganese dioxide to a considerable depth, the growth of the underground portions of the plants being increased by this treatment. This application of dioxide of manganese was termed *oxygenic fertilisation.*

The experiments carried out by the author on the elongation of roots under the chemostatic action of manganese compounds, as compared with the effect of other salts, have shown the superiority of manganese dioxide in this respect, even in comparison with sodium nitrate.

It was found that plants with fleshy tubers or roots, such as potatoes, the *Liliaceae*, etc., benefit greatly by deep treatment with manganese.

Other compounds of manganese, such as chloride, carbonate and sulphate, were recommended and used advantageously as fertilisers. In almost every case manganese chloride, a salt that diffuses very readily, produced an increase in the yield.

The plant has no real need to use manganese as a food and hence the compounds of this metal do not act directly, but as catalysers, or rather as solvents. In fact, they gave good results whenever they were associated with other nutrient substances which form essential elements of the plants, food supply.

Dioxide of manganese not only plays an active part, in so far as it liberates oxygen, but also, on being transformed into manganic acid, it serves as a solvent for the otherwise insoluble substances present in the soil and thus acts as a potent agent for their removal. Potassium, calcium and magnesia are all rendered soluble by manganic compounds. Recent experiments have shown that the potash of leucite is rendered more easy of assimilation by the simultaneous application of manganese dioxide.

It is also well known, that certain important bacterial processes in the soil are rendered more intense and rapid by the presence of manganese; such for example is the case as regards nitrification, although the denitrification of the organic matter is hindered by the manganese.

Taken as a whole, the results of these experiments prove that manganic fertilisers should be employed where there are reserves of substances requiring to be dissolved and quickly put into circulation, but if there is no such accumulation, manganese may hinder the development of the plant and retard the growth, especially of the green organs.

Certain plants derive benefit from a manganic fertiliser, while others do not, clover belonging to the latter class and white mustard to the former. In the

case of cereals, the weight of the grain, but not always that of the straw, is increased by manganese.

Thus the application of dioxide of manganese as a fertiliser can be generally recommended as a useful adjunct for rich soil, or as a means of utilising the potassic reserves present in the soil.

Leucite. *J. Giannobi, Osimo.*—This monograph deals with the Italian deposits of leucite, and the uses of this substance both in industry and in agriculture. Experiments have been made, both by the author and by other investigators, to determine the value of leucite as compared with other fertilisers. The returns obtained, in grain for the wheat, in dry fodder for the grasses, and in seeds for the beans, justify the following conclusions :—

(1) Leucite is a powerful potash fertiliser, comparable in its effects to Stassfurt salts (manure salts).
(2) Its beneficial action is most pronounced in soil that is rich in lime, less in sandy soil, and still less in clay soils.
(3) Its effects begin to be shown after the first year, and tend to increase with subsequent years.
(4) In complete mixtures a combination of leucite with ammonium sulphate is preferable to one with ammonium nitrate.

In fact leucite, either alone or associated with other fertilisers, has always held its own with other potash salts, and has occasionally given better results. The varying action of leucite on the different soils that have been tested depends upon their physical, chemical and biological variations, which are very difficult to analyse. The effect of leucite as a fertiliser tends to increase after the first year, and though it may be that the results in the second year are less satisfactory than in the first, there are cases in which the best results are given in the third year. It is possible, therefore, to ascribe the unfavourable results in the second year not so much to any weakening in its action as to the change of crop (leguminosae), for which Stassfurt salts would have been better than leucitic potash. The fact that leucite has a preference for sulphate of ammonia supports the theory of the comparative inefficacy of basic substances in lieu of leucitic potash, since it is more effective in conjunction with a salt that is physiologically acid, such as ammonium sulphate, than with a salt that is physiologically basic, such as sodium nitrate, which in the absence of leucite is not found in a complete mixture.

A German Study of the Transmission of Coat Colour in Thoroughbreds. *R. Sternfeld, Zeitschrift für Gestütkunde und Pferdezucht, Hanover.*—An account, for the use of breeders of some researches on heredity in horses, and of the practical conclusions to be deduced from them as regards the breeding of thoroughbreds. Since the colours most frequently met with in pure-bloods are bay and chestnut, both black and white being comparatively rare, researches on the hereditary transmission of coat colour are much simplified.

(*A*) BAY AND CHESTNUT COATS.—The author based his study on the data given in the "General German Stud Book" (*Allgemeines Deutches Gestüt Buch*). By selecting from this material some chestnut stallions with numerous progeny it was found that, in addition to many chestnut foals, there were a considerable number of bays, which is not surprising, seeing that many of the dams of the foals in question had bay coats. Where, however, the sires were bays there were more bay than chestnut foals among the offspring.

Although it may be suggested that this phenomenon is due to the fact that thoroughbred stallions usually have bay coats, and also are seldom mated with chestnut mares, this does not solve the question but only delays solution.

In addition to these bay sires there is a small number of stallions, also bays, occupying a special position as regards transmission of coat colour. Thus, on examining the lists of the numerous progeny of Ard Patrick, Dark Ronald, Dolomit, Fervor, Pekin, and Manners, a black or white individual is occasionally found among bay foals of all shades, but never a single chestnut.

There must, therefore, be two quite distinct classes of bay sires, seeing

that there are no intermediate stallions between those begetting many chestnut foals and those whose offspring are all bays. One of these classes produces a large number of chestnut foals, whereas the progeny of the second are all bays, no matter whether the stallions are mated with chestnut or bay mares.

It is evident that the reproductive cells of each individual contain certain factors which are different in the two classes of bay horses—that is to say, the character, presence of black pigment, is dominant as regards the character, absence of black pigment. Although the pedigrees of pure bays siring only bay offspring do not contain fewer chestnut animals than those of the impure bays, an examination of these pedigrees leads us to the important conclusion that each bay individual is the result of the union of two bay parents, whereas among the impure bays there are many horses resulting from the mating of a bay or chestnut sire or dam.

Clearly it is necessary, in order that a bay individual may appear, that one of its two parents has transmitted the factor of the black pigment characterising the bay horse. An impure bay will only have inherited this factor from one parent, whereas the chestnut animal will have inherited it from neither. Given that, as is well known, each individual receives exactly equal hereditary portions from both parents, a pure bay horse has the factor for black in each reproductive cell, the impure bay in half the cells, and the chestnut has it in none of the cells.

Thus if a bay stallion is mated with a chestnut mare it is easy to see that 75 per cent. of the resulting progeny will be bays (impure bays : pure bays = 2 : 1), and 25 per cent. will be chestnuts. On the other hand, where a chestnut is mated with an impure bay, and an impure bay with a pure bay, 50 per cent. of the foals will belong to each type.

Although in practice these theoretical results cannot be observed with the same regularity in each isolated case, yet a large number (hundreds, or even thousands) of matings between impure bay sires and dams would always give, with almost mathematical accuracy, the proportion of 75 per cent. bays and 25 per cent. chestnuts. In the same way mating impure bay stallions with chestnut mares will always produce impure bays and chestnuts in the proportion of almost exactly 50 per. cent. respectively, as is also proved by an examination of the Stud-Book.

(*B*) Black and White Coats.—The union of two black individuals may at any time give rise to chestnut or black offspring, but never to bay foals; this shows that the bay factor is dominant over the factor determining the extension of black. Consequently a black foal may be obtained from mating two bays, or a bay and a chestnut. As regards the white horse there is no question of the presence of a pigment, but, on the contrary, of its absence from more or less of the hair, whilst the skin is pigmented.

It is thus evident that mating with a white horse may at any time produce a white individual, even if the parents are impure bays. On the other hand, unless one of the parents is white, the foals will never be white.

(*C*) Practical Conclusions.—The practical consequences resulting from these laws of transmission can only be considered to a limited extent in actual breeding operations. Nevertheless they enable paternity to be established with certainty in cases where it is doubtful. They also show perfectly clearly that each individual transmits only what is present in its reproductive cells, but that none transmits better or worse than another, *i.e.*, prepotency is of no account in the transmission of coat-colour. On the other hand it would be a mistake to regard other characters as necessarily correlated with the colour of a horse's coat. A white animal may transmit the colour of its coat to all its offspring without transmitting its other characters to the same extent.

The author then discusses the alleged inferiority of pure-bred mixed bays as racehorses, which he proves to be a fallacy by reference to some lists of famous mixed (or impure) bay stallions and mares in Germany. Finally, in discussing the somewhat prevalent idea that, in the progeny of certain stallions and mares, a particular coat-colour regularly denotes a more satisfactory individual than other shades, and that the coat-colour may be a visible token of the transmission to an unusual extent of the prepotency of an ancestor having

a coat of the same hue, the author remarks that though it may be possible to conceive that some connection exists between colour and performance (such as in racing), no such correlation has ever been established as regards the numerous characters determining the racing capacity of thoroughbreds.

In the author's opinion the importance of these laws of colour inheritance consists in the fact that the hereditary characters of an animal cannot be influenced by any ancestor, but, on the contrary, the genetic constitution of the individual depends solely upon the characters directly transmitted to it by its sire and dam.

Identification of Cows. *C. L. Enos, "Dactylography" (summarised in "Nature").*—In the fourth number of *Dactylography*, a journal devoted to the study of finger-prints, Mr C. L. Enos, Superintendent of the State Bureau of Criminal Identification, Colorado, states as the result of his experiments that, as the human being can be identified by his finger-prints, it is reasonably certain that the pattern or design which nature has provided at the end of every cow's nose may be made to serve the same purpose. Up to the present no precise classification has been worked out, and this will be necessary before such prints can serve a practical purpose. The noses of several calves have been printed each month for one year, and if further experiments show that these patterns persist during the life of the animal, it will supply a practical means of identification which will be valuable to all breeders and to the police.

Contribution to Knowledge of the Toxic Products of New Hay. *E. Zchokke, Schweizer Archiv für Tierheilkunde.*—Although it is well known that new sweating hay sometimes disagrees with animals, especially horses, the scientific explanation of this fact has so far little foundation. The author, who bases his statements upon Lauppers' observations on the spontaneous combustion of hay, concludes that in new hay chemical decomposition takes place, resulting in the formation of extremely toxic substances. This decomposition is due in the first place to the action of enzymes, which on being set at liberty in the dying plant, cause a rise of temperature varying from 40° to 45° C.

At this temperature, the conditions are favourable to the growth of many fungi that at once produce actual fermentation. During this time evaporation takes place in the hay, and the water condenses on the cold parts. Probably metals such as iron and manganese, that can act even if only traces are present, bring about, like actual catalysts, oxidation phenomena (raising the temperature to 280° C.) thus causing the formation of different new products. It is doubtless the iron which plays the rôle of fire-carrier and induces the ignition of the heated hay.

The products of this chemical decomposition are volatile compounds, ethereal oils, and although these gradually evaporate and finally completely disappear, while present they endow the hay with certain toxic properties. The author further mentions a fact showing that toxic products can be formed even in old hay, if it be exposed to great heat. A fire having broken out in a barn, sixty-five cattle were taken back to the cow-sheds some days later. Suddenly fifteen of these animals were seized with diarrhoea, drowsiness, violent palpitations of the heart, while eczema made its appearance on their backs, etc. The origin of all these symptoms could be traced to the rain-water dripping off the barn after having passed through the heated hay that was even partly carbonised by the fire. The drops falling on the animals skin cause actual dermatitis, and gave rise to internal troubles when they found their way into the food of the feeding-troughs. Experiment proved that this water had fatal effects upon rabbits and mice.

All the observations made on the formation of these poisonous substances may be summarised as follows:—The quality and quantity of the new products arising in fermenting hay depend on its composition and degree of maturity, the micro-organisms developing in it and the intensity of the fermentation process.

Since this phenomenon cannot be prevented, the time-honoured precept of never using new hay till three months after it has been made, should be scrupulously obeyed.

Warble-Flies and Cattle. *G. H. Carpenter, "The Irish Naturalist."*—Some doubt has always been entertained regarding the way in which the larval stages of warble-flies gain access to the bodies of cattle in which, for a considerable portion of their existence, they are to be parasitic. Almost ten years ago a series of experiments carried out in Ireland seemed to indicate that the old idea, that the larvæ gained access by the mouth as a result of the licking of the egg-infested spots, was inaccurate and at any rate not always the case; and that, instead, the young maggots actually bored through the skin of legs near the place where the eggs were laid, and made their way through the tissues to the gullet, whence they journeyed to their final resting places, beneath the skin of the back. Recent observations strongly confirm these conclusions. If the larvæ enter by the mouth, muzzling should be a preventive; yet, of nine muzzled calves, fed along with seven unmuzzled calves in 1914, the former contained in 1915, 261 warble-maggots, an average of 29, and the later only 62, an average of 9. Further, calves were fed with young living larvæ of warbles, six calves having 100 each, but these calves showed, on later examination, entire absence of warble-maggots.

The most interesting and conclusive experiment, however, was carried out under more natural conditions. Four calves were placed in a field where warble-flies were busy, but all their bodies were protected by coverings except the hind limbs. They were kept under close observation for an hour, and then were brought back to shelter where they remained. One calf was seen to have been "struck" 187 times by a female warble-fly, and it was found later to contain forty-one maggots belonging to the same species; another struck seventy-three times had twenty-three maggots; another struck fourteen times had thirteen maggots. Now the calves were so muzzled and tethered that they could not possibly lick those parts of their hind limbs, below the hock, on which the warble-fly eggs were laid. We are therefore driven to believe that the larvæ which hatched from the eggs, gained access to the bodies of the calves by boring directly through the skin. Moreover, it is wrong to suppose that only eggs laid upon the back give rise to larvæ which complete their development, for clearly even eggs laid low on the hind legs can successfully complete their emigrations within the body, finally forming the nodules under the back, from which the adult flies emerge.

Foot-and-Mouth Disease; Possibility of the Existence of Two Forms. *Schein; and Vallée and Carré, Compt. Rend. Ac. Sci., Paris.*—Although evidence has not been produced sufficient to prove his case, Schein suggests the possibility of the existence of two forms of foot-and-mouth disease: one a mild form, non-transmissible to man or other animals, and having no serious effects; the other an acute form, with a short incubation period, severe in its attack, and capable of transmission to man or pigs. Experiments carried out by other workers seem to give some support to this view. Heifers which had passed through and were cured of an attack of foot-and-mouth disease, of either natural or experimental origin, were subsequently tested with two different lots of virus. When the French virus responsible for the original infection was injected, no animal became infected; when a virus imported from Germany was used, all the animals experimented with became reinfected, contrasting results which clearly suggest a qualitative difference between the two kinds of virus.

A New Method of Selecting Milch Cows. *N. Maupas, Jour. d'Agri., Pratique.*—The correlation which, according to recent researches, seems to exist between chest development and lactic secretion in cows, has long escaped the notice of breeders of milch kine, and instead of selecting for breeding such cows only as were generally symmetrical, it was at one time the fashion to choose animals in which the hind were far more developed than the fore quarters. Hence far from being considered as a defect, a poorly developed, or even narrow chest, began to be regarded as a beauty, while in the same animals a broad pelvis was another much admired characteristic.

The method devised by Dr Paul Schuppli, Director of the School of Agriculture and of Stock Breeding at Grabnerhof (Austria), for classifying the

animals to be registered in the herd-book of the society during the war has been applied on a large scale by the Gröbning Breeding Syndicate to the Pinzgau breed. Like all such methods, it is based on the general appearance of the animal, after which, this being the important point, the width of the chest is compared with the height at the withers.

Each animal in which the required characters of development are combined, is marked according to a very definite scale of points. The lowest mark that can be given is 1, indicating that the chest width of the animal examined is one-third of its height at the withers. When the chest measurement exceeds this amount the cow is credited with another mark for each centimetre of extra width.

As a rule mark 5, which denotes exceptional characters in the animal measured, is rarely given. Investigations carried out under the auspices of the Gröbning Breed Society have shown that *very many cows were not credited even with* 1 *mark*, and that such animals *should be excluded from the herd-book*.

The following table gives some figures collected by Mayer, an agriculturist of Oberstuttern, *before* and *after* this method of selection was adopted, and they seem to confirm Dr Schuppli's views on the question. From 1916, Mayer measured his cows in the manner prescribed by Dr Schuppli, and in consequence, reduced the number of head in his herd to nine; but the latter were all entitled to mark 5.

Year.	No. of Cows.	Average Annual Milk Yield.	Average Fat Content of Milk.
1912 . , .	12	2·557 litres.	3·85 per cent.
1913 . . .	12	3·065 "	4·01 "
1914 . . .	12	2·914 "	4·03 "
1915 . , .	11	2·866 "	4·29 "
1916 . . .	9	3·507 "	3·97 "
1917 . . .	9	3·404 "	4·28 "

It should further be mentioned, that two bulls belonging to Mayer, and aged respectively eighteen months and two years, were marked 5 on their registration in the herd-book.

The milk yields due to the application of this method are all the more interesting, seeing that the animals kept by Mayer received absolutely no concentrates (cake, grain, etc.), and during the winter were given two feeds of hay, or the aftermath of the natural pastures only per day, while in summer they lived entirely on the grass they cropped on the meadows belonging to the farm.

Cows of the Pinzgau breed, reared on the mountains in Austria, weigh 400 to 450 kg., and yield from 1200 to 1700 kg. of milk only each year; the cows of the valleys weigh from 650 to 750 kg., and give from 2000 to 2800 kg. of milk a year (Professor Werner), but even these figures are below those obtained at Mayer's farm.

Dr Schuppli and the breed syndicates of his district advise the adoption of the above-mentioned measurement method, but also advise an examination of the animals to see whether they are normal as regards width of pelvis, depth of chest, body length, etc. In this connection the proportions fixed for the milch cow by Professor Dechambre will be of the greatest use (occipital-coccygeal length as compared with oblique circumference of the chest; the distance between the haunches as compared with width of skull, etc.).

The Value of the Reductase Test in the Dairy Industry. *Chr. Barthel, Le Lait, Lyons.*—Among the methods of testing milk the methylene blue reductase test has again become the subject of much discussion. Two main objections have been raised, viz.—(1) In the case of milk from isolated cows discoloration sometimes takes place very rapidly, although the milk contains but an insignificant number of bacteria; (2) it is not a perfect method for determining the number of bacteria present in milk.

The author, in discussing these criticisms, states that as regards the first a thorough examination has shown that all milks which changed colour very rapidly (that is to say before two hours had elapsed) were abnormal. They had a high catalasimetric index, an abnormal number of leucocytes, or were the products of cows that were in the very last lactation period.

Lind has made similar statements. As, however, in the dairy industry the reductase test is applied exclusively to mixed milk, the product of several cows, the first objection has no real weight. As regards the second, the author urges that the reductase test is purely practical. Further, if the results obtained by Breed or Skear by directly counting the bacteria under the microscope, are compared with Barthel and Orla-Jensenn's computation based on the length of the methylblue reaction it will be found that in about 90 per cent. of the cases the estimated number of bacteria in the milk is identical. This is a fairly good proof of accuracy; moreover, when the milk of different retail sellers has been subjected several times to this method of examination, the discrepancies have in practice proved to be negligible.

In the case of milk supply to towns and large dairies, the first *desideratum* is that the methods adopted should be practical and simple, so that a large number of samples can be examined at once, especially from the point of view of their keeping properties. Hitherto no method has for this purpose proved superior to the reductase test. In addition, this method could serve as a basis for payment according to quality, on the condition that the price be fixed by the average number of marks accredited to each seller during a certain period of consignment. In this way, the small irregularities inseparable from the method are eliminated, and have no effect upon the final verdict.

A Method for the Preliminary Detection of Abnormal Milk Based on the Hydrogen Ion Concentration. *J. C. Baker and L. L. Van Slyke, Jour. of Biol. Chem.*—The method described by the authors is based upon the use of the dye brom-cresol purple, previously suggested by Clark and Lubs as a substitute for litmus for use in milk cultures. A drop of a saturated water solution of the dye is added, and the colour is then observed. In the case of average milks of normal character, the colour becomes bluish-grey. If the colour is distinctly lighter or darker, there is ground for suspecting the quality of the milk. The colour ranges from a bright yellow at one extreme to a deep blue at the other. The colour is made lighter by the presence of acids, acid salts, formaldehyde solution, and also by heating above the usual point of pasteurisation. It becomes a deeper blue in the case of milk from diseased udders, watered milk, skimmed milk, and milk containing additions of alkali or an alkaline salt.

Attention is called to certain conditions which modify the characteristic colour given by brom-cresol purple solution with average normal milk. The presence of extra fat (5 per cent. or more) gives an appreciably lighter colour than is the case with ordinary market milks containing 3 to 4 per cent. of milk fat. Skimmed milk gives a darker colour than the same milk before the removal of fat. With milks drawn directly from the cows on fresh pasture, the colour is a decided yellow which modifies the colour reaction with brom-cresol purple.

The utility of this method has been demonstrated by the testing of 570 samples of market milk.

The authors emphasise the fact that the application of the brom-cresol purple test is not to be regarded as final but only as preliminary and suggestive. Milks giving a normal coloration will then be considered as normal; and a sample showing an abnormal coloration can be put aside and submitted to careful examination in the laboratory. The chief value of the brom-cresol purple test lies in the fact that when properly used, it will greatly minimise the work involved in official milk inspection.

"Mottles" in Butter, their Causes and Prevention. *O. G. Hunziker and D. F. Hosman, Jour. of Dairy Science.*—Butter instead of being of a uniform colour is sometimes traversed by waves or streaks of different shades, or covered with patches. In the latter case, when deep yellow translucent

blotches interspersed with whitish opaque spots make their appearance, the butter is said to be "mottled."

Although mottles in butter have no effect upon its flavour, keeping quality and wholesomeness, they greatly depreciate its market value.

The authors give a summary of the previous investigations made for the purpose of discovering the causes of this defect, and afterwards describe their own experiments which consisted in: churning at different rates, stopping churning in all cases when the granules of butter had attained the size of wheat grains; washing or not washing the butter; salting it or not salting it; examining under the microscope the product obtained.

It was found that mottles appear in salted butter in which the working had been incomplete or lacking in uniformity. In mottled butter the deep yellow patches contain relatively few and rather larger water droplets, while the white patches contain large numbers of very minute droplets. The authors conclude that salt disturbs the emulsion of water-in-fat in butter, and that the uniformity of the emulsion can be restored by the proper working of the butter.

In order to prevent mottling, butter must be worked sufficiently to accomplish the fusion and re-emulsification of the water and brine. This point is usually reached when the butter has been reduced by working into a thick plastic and tough consistency. The working must be uniform throughout the churning; therefore sufficient workers should be employed to deal with the amount of butter to be made.

German Experiments on Feeding Pigs with Rations containing Large Quantities of Fish Meal. *K. Müller, Deutsche Landwirtschaftliche Tierzucht.*—With a view to deciding to what extent the amount of fish meal could be increased in fattening pigs without detriment to the health of the animals and the quality of the meat, experiments were carried out in 1920-1921 at the experiment farm at Ruhlsdorf for the keeping, feeding and breeding of swine.

The experiment was divided into two periods, each lasting four weeks. During the first period the animals were fed fish meal, potatoes and beets, and during the second potatoes entirely took the place of the beets. Eight pigs, born in July and August respectively, which weighed at the end of the year 50 kg. on an average, were used; five of the animals belonged to the improved native breed, while the three others were crosses between it and Yorkshires, Berkshires, or Hildesheim pigs.

During the whole period of observation the animals showed no serious symptoms, which is a fact worthy of notice, seeing that they consumed large quantities of fish meal containing much more sodium chloride than is normally present in commercial meal. The composition of the meal used in the experiments was as follows:—Crude protein, 60·20 per cent.; crude fats, 1·17 per cent.; sodium chloride, 6·43 per cent.: the crude protein content was thus higher than the average (52·5 per cent.), whereas the crude fat content was below the average (2·1 per cent.), which had much to do with the fact that the quality of the meat and fat of the animals fed on this flour was not affected.

The pigs consumed considerable quantities of this ration (upon which they were exclusively fed), seeing that their daily food contained as much as 0·39 kg. of fish meal. Assuming the percentage of digestible protein to have been at least fifty, each animal thus consumed in the fish meal 200 gm. of digestible protein.

The ration contained nearly exactly the amount of digestible protein (255 gm.) and the starch values (2·05 kg.) necessary according to Kellner to fatten pigs, so that the increase in live-weight ought to have been sufficient. It was not so, however, for the average only rose to 621 gm. per day, whereas in other fattening experiments made in the winter of 1920-21 at the experiment farm, the daily increase in live-weight was 840-920 gm., being thus from 200 to 300 gm. more than when the pigs were given large amounts of fish meal.

From what has been said, it is evidently possible to fatten pigs on rations consisting exclusively of potatoes and fish meal; a satisfactory result must,

however, not be expected. It is probable that the animals would have put on more flesh if only half as much fish meal had been given them (200 gm.), other foods rich in protein being substituted for the remaining half.

An estimate of the returns shows that considerable quantities of food are necessary to produce 1 kg. increase in live-weight, at all events during the first period. As regards the second period, however, the amount of food consumed is more in accordance with the figures obtained in previous fattening experiments. In any case the experiment cannot be said to have been successful from this point of view.

Treatment for Stomach Worms in Sheep. *J. E. Guberlet, Oklahoma Sta. Bull. 137*).—After summarising the history and habits of the stomach worm of sheep (*Hæmonchus contortus*), the author proceeds to discuss modes of prevention and cure, and describes two successful remedial measures tested at the laboratory of the Station. The simplest remedy is a 1 per cent. solution of copper sulphate in water; and of this solution 1¾ oz. should be the dose for lambs, and 3½ oz. the dose for sheep over a year old. This remedy, as subsequent dissection showed, removed 75 to 97 per cent. of the worms present, but it was less effective and less rapid in its action than the following mixture of copper sulphate (1 per cent.) and tobacco infusion (1 per cent). "Dissolve ¼ lb. of powdered crystals of copper sulphate (bluestone) in ½ gallon boiling water, using porcelain or enamelware dish. Put ¼ lb. of finely-ground or powdered tobacco (tobacco snuff) into ½ gallon boiling water, cover, and let stand overnight. In the morning mix the two solutions in a wooden, earthenware, or non-metallic receptacle, and add 2 gallons cold water. This makes a solution of proper strength to use, and will be enough to dose 100 adult sheep or 200 lambs, allowing 10 per cent. waste." The dosage is the same as that given above for the copper sulphate solution, and the efficacy of the mixture is such that 90 to 100 per cent. of the worms are removed.

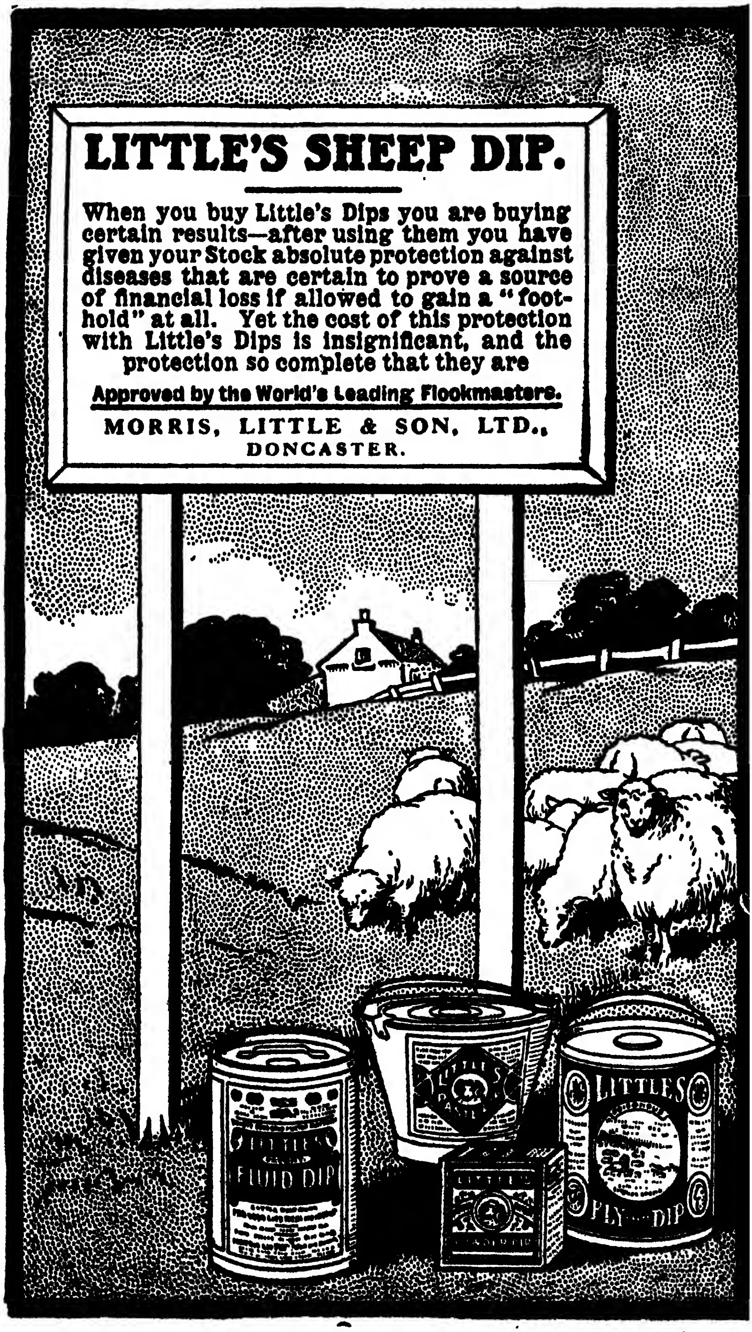
The Effect of Electric Lighting and Climate on Egg Production in Canada. *M. C. Herner, Agric. Gaz. of Canada.*—In the report on the Poultry Husbandry Department of the Manitoba Agricultural College, a description is given of the work carried out by the "poultry plant" branch. In addition to other work still in progress experiments have been made concerning—(1) the effect of electric lighting on egg laying; (2) the effect of climate on the annual egg production.

I. EXPERIMENTS ON EFFECT OF ELECTRIC LIGHTING ON EGG LAYING.—These experiments extended over three winters with white Leghorns and Barred Rocks. The results obtained clearly show that the use of electric light possesses certain distinct advantages for winter laying; the use is limited to the months of October to December, but the birds whose quarters are lighted lay many more eggs for which higher prices are paid, and the total revenue for the year is far superior to that expected from birds not subjected to light.

II. EFFECT OF CLIMATE ON EGG PRODUCTION.—Experiments made in co-operation with the Poultry Department of the North Carolina Agricultural College at West Raleigh (U.S.). In August 1919 twenty-five White Leghorn pullets, belonging to a heavy-laying strain, were sent to West Raleigh; twenty-five pullets of the same age were reserved for the Manitoba Service. Both pens were fed exactly alike; the climate was the only difference.

The difference in favour of the North Carolina climate was 633 eggs, or an average of 25·3 eggs per hen more than Manitoba. The observations made during this experiment encourage the hope that it will lead to quite an elaborate system of co-operative experimental work between the poultry departments of the different agricultural colleges, and result in much closer co-operation than has existed hitherto.

The Destruction of Pigeon Lice. *H. P. Wood, U.S. Depart. Agr. Circular* 213.—The author has perfected a method whereby complete eradication of lice from a flock of pigeons may be accomplished. The method consists in dipping each pigeon and squab in a solution composed of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commercial sodium fluoride, 1 ounce; laundry soap (hard), ¾ to 1 ounce; and 1 gallon of water. The sodium fluoride may be measured by using four level teaspoonfuls to a gallon of water. The body of the pigeon must be submerged until it is soaked to the skin—a process taking only ten to fifteen seconds if sufficient soap has been added—and then the bird's head is quickly ducked under, and the bird set free A hot day in the middle of summer is recommended, and the birds must be dipped early in the day to give ample opportunity for thorough drying before nightfall.

If it is wished to keep the flock clean after such treatment has been carried out the birds must not be allowed to come in contact with stray pigeons; and every new pigeon introduced to the flock must be similarly treated before introduction. Should complete eradication not be aimed at, but only the destruction of the majority of the lice, a pinch of sodium fluoride should be put well in amongst the feathers of a bird in several places. This dry method has the advantage that it can be applied at any season of the year; but, as the powder has irritating properties, the birds should be dusted in the open air, and the operator should protect himself by tying a moist cloth over his nose.

Acarine Disease in Bees. *J. Rennie, Bee World.*—In a series of short articles Dr Rennie discusses many aspects of the problem of acarine disease in bees. The life history of the parasite is described, and some facts of considerable importance from the parasitical point of view have been elucidated. The method by which bees become infected has been in some doubt; but the author states that while many of the mites remain within the tracheæ of an infected bee, others, and particularly fertilised females, pass to the outside of the host, whence they may easily reach another bee by contact. Evidence all points to the probability that the disease is almost entirely a contagious one, carried from an infected to a clean bee, or carried to a clean stock by means of infected robber bees, drones, or casual wanderers entering a wrong hive. The author deprecates the keeping of stocks known to be diseased through winter. As a preventive to the spreading of infection he recommends that grass, where crawling bees, known to have acarine disease, are present in numbers, should be cut close, raked and burnt, and that a strong-smelling, repellant substance, such as naphthaline, should be sprinkled for the purpose of preventing healthy bees from alighting on infected ground. But such infectivity is only of short duration after crawling has ceased, for mites cannot live long away from the living bee, the general period being only twenty-four to thirty hours.

Control of American Blight (Woolly Aphis) by an Imported Parasite. *Comp. rend. Acad. Agr. France.*—The Woolly Aphis, a so-called American blight of apple trees, has become increasingly common, and is extending its range. There is much need, therefore, for a successful means of checking its ravages, and the experiments now being conducted in France and aiming at control through the agency of an imported parasite, will be watched with interest. So far as they have gone the experiments have been successful—an American parasite of the Woolly Aphis, a Chalcid, *Aphelinus mali*, was imported in small quantity to Paris, and was bred carefully and successfully. So numerous were the individuals, after only a few generations, that colonies were established in various country places, which in turn became breeding and dispersal centres. While the parasite seems, in its present numbers in France at any rate, to be unable entirely to check the multiplication of the Woolly Aphis during the great growth activity of spring and early summer, the results of its presence are very evident in well-established centres in autumn, when large numbers of the Aphis turn black, showing that they have been parasitised.

OFFICIAL ORDERS AND CIRCULARS.

THE following notices were issued to the press during November :—

Scheme for Land Improvement and Drainage Work for the Unemployed, 1922-23.

Unemployment Relief Schemes.

1. In order to provide work for the unemployed in districts where serious unemployment exists, the Board of Agriculture for Scotland have been authorised, subject to the necessary funds being voted by Parliament, to provide financial assistance for the execution of works of field and arterial drainage, including such operations incidental to drainage as the removal of trees, hedges, whins, etc., and the provision and improvement of water supplies to farms and groups of farms. As the object in view is to meet unemployment so soon as it may become acute, it is desirable that applications should be lodged (in accordance with paragraph 9) ***without undue delay.*** No application will be considered which reaches the Board after 16th December 1922. Applications by telegram or applications sent in without full details of the works proposed to be carried out will not be considered.

2. The Board's grant cannot exceed (*a*) half the cost of the work ; (*b*) in the case of drainage, a maximum payment of £10 per acre of land improved ; or (*c*) an amount equal to the sum paid in wages to the unemployed men engaged, whichever of these amounts is the least. In the case of water supplies, any proposals involving a high cost as regards skilled labour, *e.g.*, the sinking of artesian wells, will not be considered ; and no scheme for the provision or improvement of water supply can rank as eligible for grant unless the estimated cost of unemployed labour is at least equal to the amount of the grant applied for. Subject to the condition that the essential object of the Government contribution is to provide relief for unemployment, the Board will give a preference to cases in which the proprietors or tenants of adjoining lands combine for the purpose of carrying out a co-ordinated scheme of drainage, including the improvement of water courses which are of common interest to the lands concerned.

3. Work shall be done as far as possible by hand labour, so as to absorb the maximum number of unemployed men.

4. The Board's contribution will be paid only in respect of works carried out by means of unemployed labour obtained as stated in paragraph 5.

It is expected that, where possible, the work will be undertaken entirely by unemployed labour. If any regular skilled men are employed for the purpose of supervision or otherwise, the number should be the barest minimum.

5. Labour must be obtained through the Labour Exchange, or must be composed to the extent of 75 per cent. of unemployed ex-service men. Of the remaining 25 per cent. a majority must be married men, if available.

6. The wages paid must not exceed the current rates of unskilled agricultural labour in the district, or 75 per cent. of the current rate for adjacent urban unskilled workers.

7. Subject to additional funds being voted by Parliament for expenditure after 31st March 1923, payment of grants may be made by the Board in respect of work done up to 30th April 1923, ***but in no circumstances will any payment be made by the Board for work done after that date.***

8. Forms of application for grants may be obtained from the Board or from the Local Authorities.

9. The applicant will complete the form in duplicate, and transmit it, together with relative plans in duplicate, to the Local Authority, who will scrutinise the application from the point of view of the labour proposals, and make any observations on these and otherwise on the application as the Local Authority may consider appropriate.

10. The Local Authority will then forward the application to the Board, who will scrutinise it from the technical aspect, and inspect as they think fit.

11. The Board, on approving an application, will intimate approval simultaneously to the Local Authority and the applicant; returning to the latter one copy of the approved application with plans, and to the Local Authority particulars of the approved application. In all cases the Board's approval to the commencement of works must be obtained, otherwise such works will not rank as eligible for grant under the scheme.

12. Claims for payment of grant must be completely supported by vouchers showing the whole cost of the works for the period in respect of which the claim is made. Receipts for wages should show rate of pay and period covered by payment.

Forms for claiming payment of grant will be obtainable from the Board and, when completed by the applicant, shall be forwarded by him through the Local Authority, who should certify whether the conditions set out in paragraphs 4, 5 and 6 have been complied with.

13. "Local Authority" in this Memorandum means the County Council. County Councils should, however, keep in touch with Town Councils in order that the question of engaging unemployed men resident in Burghs as well as in the landward area may be considered.

On 15th December the following press notice was issued announcing extensions to the scheme for the relief of unemployment.

The Board of Agriculture for Scotland direct attention to the following extensions which they have been authorised to make in the above scheme, the conditions of which have already been announced in the Press:—

1. The closing date for receiving applications has been postponed from 16th December to 31st January 1923.

2. Subject to the necessary funds being voted by Parliament, payment of grants on approved schemes may be made by the Board in respect of work done up to 31st May 1923.

3. Subject to the conditions of the above scheme and the foregoing provisions, the Board will be prepared to consider applications for grants in respect of the improvement of roads in private ownership which are used for purposes of agriculture and forestry. The Board's grant under this head cannot exceed—

(*a*) Half the cost of the work,

or

(*b*) An amount equal to the sum paid in wages to the unemployed men engaged, whichever of these amounts is the less.

In all cases the Board's approval to the commencement of works must be obtained, otherwise such works will not rank as eligible for grants under the scheme.

Full particulars of the scheme can be obtained on application to the Board of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh (or to the Clerks of the County Councils).

THE following letter was issued recently to Town Clerks and Clerks to Parish Councils in Scotland:—

THE ALLOTMENTS (SCOTLAND) ACT, 1922.

Allotments.

SIR,—I am directed by the Board of Agriculture for Scotland to direct the special attention of your Council to the amendments of the law relating to allotments embodied in the Allotments (Scotland) Act, 1922, which became law on 4th August, and which is referred to in this circular as the "new Act."

PREVIOUS STATUTES AFFECTED.

The Statutes affected by the passing of the new Act are the Allotments (Scotland) Act, 1892; the Local Government (Scotland) Act, 1894 (Part IV.); the Land Settlement (Scotland) Act, 1919 (Part III.); and the Agriculture Act, 1920. In each certain sections have been repealed (*vide* First Schedule), but some of these reappear in the new Act in another form. A noteworthy instance is Section 26 of the Act of 1894, some of the more important provisions of which are repeated and made applicable to Town Councils as well as

to Parish Councils, viz., in Sections 6 and 7 and the Second Schedule of the new Act.

STATUTES TO BE CONSTRUED WITH THE NEW ACT.

The new Act and the enactments mentioned in the preceding paragraph (other than the Agriculture Act) form the new code governing the provision of allotments by Local Authorities in Scotland. They are to be known together as the Allotments (Scotland) Acts, 1892 to 1922. Some progress has been made, however, towards codification.

SCOPE OF THE ALLOTMENTS (SCOTLAND) ACTS.

Town Councils and Parish Councils are retained as the Local Authorities entrusted with administration of the Acts.

The new Act applies to allotments and to allotment gardens, between which a distinction is drawn as to size. An allotment garden is defined as meaning "an area not exceeding 40 poles, which is wholly or mainly cultivated by the occupier for the production of vegetable crops for consumption by himself or his family, and is not let to the occupier during his continuance in any office, appointment, or employment held under the landlord or let along with any dwelling-house." In the Allotments Acts as a whole, except certain relatively unimportant provisions of the Act of 1892 (viz., Sections 7 (3) and 7 (6) and the proviso to Section 8 (2)), and unless the context otherwise requires, the expression "allotment" is to include an allotment garden so defined. It is important in reading the new Act to note which provisions apply both to allotments and allotment gardens, and which only to one or the other. The distinction between allotments and allotment gardens is in fact the chief feature of the new Act, the main purpose of which may be said to be to fix or define the tenure of the holders of the small plots (called allotment gardens) now so common in urban areas. The land cultivated by a large number of such holders is feuing land which may be required on comparatively short notice for building purposes. It was, therefore, deemed expedient to effect a compromise between the legitimate exercise of powers of resumption and the reasonable demands of the holders for fixity of tenure. It has been accordingly provided that while the holders' tenancy shall not be an absolute bar to resumption, resumption may be effected only (*a*) after the giving of six months' or longer notice, (*b*) (in the case of land required for certain industrial purposes or public undertakings or under the Housing (Scotland) Acts) under powers contained in or affecting the lease of the land. Compensation is recoverable if the tenancy is terminated by the lessor (1) between 1st May and 1st November where at least six months' notice is required, or (2) by resumption of possession at any time in any other case under heading (*b*). On the other hand, irritancy of the lease by the tenant or breach of the Local Authority's regulations may create grounds for resumption by the lessor without payment of compensation.

POWERS AND DUTIES OF LOCAL AUTHORITIES.

(1) *New Powers and Duties:*

(*a*) Entry on unoccupied land: Important powers are conferred on Local Authorities under Section 10 of the new Act. These are a renewal of similar powers temporarily conferred on Town Councils during the War by Defence of the Realm Regulation 2L. Local Authorities are authorised, after giving the requisite notice, to enter on unoccupied land for the purpose of providing allotment gardens thereon, to adapt the land, to let it to a tenant or to an allotment association, and on the termination of occupation to remove any erection or work of adaptation. The Local Authority's right of occupation is regulated, and any person interested in the land is permitted to make a claim should he suffer loss by the Local Authority's action. Unoccupied land is defined as meaning "land in respect of which no person is entered as tenant or occupier in the valuation roll in force at the date of the notice of intended entry, and which has not been let and

occupied subsequent to the making up of the valuation roll and before the date of the notice."

(*b*) Access to Allotments : A Local Authority providing allotments is required to provide for access thereto by suitable roads or paths where such are not already available, and to regulate access thereby by regulations under the Allotments Acts.

(2) *Amendment of Existing Powers and Duties :*

(*a*) Section 2 (1) of the Act of 1892 : It is no longer necessary for a Local Authority before proceeding under the Allotments Acts to be of opinion that allotments cannot be obtained at a reasonable rent and on reasonable conditions by voluntary arrangements between the owners of suitable land and the applicants.

(*b*) Leasing of Land : Where land is leased by a Local Authority for use as allotments or to be sublet for use as allotment gardens attention must be given to Section 6 of the new Act, which deals with such questions as the size of the allotments, erections to be permitted, the breaking up of permanent pasture, and resumption of the land by the landlord for certain specified purposes. Where the land is let for use as allotment gardens the restriction as to size indicated in the definition of an allotment garden applies, but it is to be noted that Section 5 permits of one person holding two or more allotment gardens if their aggregate extent does not exceed 40 poles. In the case of land acquired after the passing of the new Act the Board may authorise a Local Authority, without the landlord's assent, to break up permanent pasture or to permit it to be broken up.

(*c*) Restriction applying to certain Town Councils.

Section 12 enacts that in a burgh where the population is ten thousand and upwards the obligation of the Town Council under the Allotments Acts is to be limited to providing allotment gardens not exceeding 20 poles in extent.

(*d*) Acquisition of Land for Common Pasture.

The sections of the Acts of 1892 and 1894 dealing with the provision of land for common pasture are replaced by the simpler provisions of Section 7 of the new Act.

COMPULSORY ACQUISITION OF LAND.

Local Authorities retain the right of applying to the Board for authority to acquire land compulsorily, but certain important alterations have been made in procedure, Section 21 of the Act of 1919 being repealed. Where a Local Authority is unable by agreement to purchase suitable land at a reasonable price application may be made to the Board for an Order authorising compulsory purchase. Similarly where suitable land cannot be obtained on lease authority to lease compulsorily may be sought. In the latter event, however, the leasing is subjected to restrictions where the land is held by a corporation or company for the purpose of a railway, dock, canal, water, or other public undertaking. A lease effected compulsorily is to be for a period of not less than ten nor more than thirty-five years. Provision is made for assessment, at the termination of the tenancy, of compensation due by the landlord or by the Local Authority and certain subjects, such as mines or minerals, are excluded from compulsory leasing.

A further important amendment is made by Section 13, which requires a Local Authority to serve the requisite notice to treat under a Compulsory Order issued by the Board within three months of the issue of the Order, otherwise the Order becomes null and void, and may not be renewed within three years except under special circumstances.

The First Schedule of the Act of 1919, which applies in the case of compulsory acquisition of land, is amended by the introduction of provisions specifying *inter alia* the powers of the official arbiter in the case of an Order

for Compulsory Leasing. These provisions are quoted in full in the memorandum enclosed with this letter.

Establishment of Allotments Committees.

Section 9 of the new Act renders it obligatory in any burgh with a population of ten thousand or upwards for the Town Council, unless exempted by the Board, to establish an allotments committee, to which all matters relating to the exercise and performance by the Council of their powers and duties under the Allotments Acts as respects the provision of allotment gardens (except the power of raising a rate or borrowing money) shall stand referred. The functions and composition of such committees are defined. In accordance with the interpretation clause of the Act the reference to population in this section must be construed as to the population of the burgh according to the published returns of the last census for the time being. No time limit is fixed by the Act, which apparently contemplates the establishment of committees forthwith in all burghs to which the section applies. The Board desire me to direct particular attention to this section. They would be glad to be informed as soon as possible by the Town Councils affected thereby of the steps taken to comply with the terms of the Act. Any application to the Board by a Town Council for exemption from the duty of establishing an allotments committee should be accompanied by a full statement of the grounds on which such exemption is sought.

Rating of Allotments.

Attention will require to be given by Local Authorities to the provisions of Section 17 with regard to the rating of allotments.

Provisions Specially Applicable to Allotment Gardens.

These are very important. In addition to those already referred to they include Sections 1 and 2 of the new Act, which deal with the termination of the tenancies of land let by or to a Local Authority and the closely related question of the compensation payable to the tenant (whether Local Authority, Allotments Association or other person) in the event of removal. The extent to which these sections apply to current tenancies should be noted.

Section 3 dealing with the application of the foregoing sections to Crown Lands, including land taken under the Defence of the Realm Regulations, and Section 11 relating to the determination of questions arising on the resumption of land are also important.

Limitation of Expenditure and Rents.

Under Section 16 of the new Act a Local Authority may not take any proceedings under the Allotments Acts unless the expenses incurred may reasonably be expected to be defrayed out of receipts. For the purpose of the section expenses exclude (1) expenses in relation to the acquisition of land other than the price, feu-duty, ground annual, or rent, or other compensation payable in respect of the land; (2) expenses incurred in making roads to be used by the public; and (3) sinking fund charges in respect of loans raised in connection with the purchase of land. It is to be noted, however, that expenses and receipts include expenses and receipts in respect of land acquired either before or after the passing of the new Act, thus permitting a Local Authority to "pool" the expenses of and receipts from all schemes for which it is responsible, and so to set off a loss from one scheme against a surplus from another. To this extent the section renders less absolute the principle embodied in Section 2 (2) of the Allotments (Scotland) Act, 1892, that the expenses of a Local Authority in acquiring and adapting land for use as allotments should be recouped out of the allotment rents.

Calculation of receipts and expenses is to be done in such manner as in the case of a Town Council, the Secretary for Scotland, and in the case of a Parish Council the Scottish Board of Health may direct.

Land let by a Local Authority under the Allotments Acts for use as an allotment is to be let at the fair rent for such use.

Financial Provisions.

Where money is borrowed by a Local Authority for the purpose of purchasing land for allotments the maximum period for the repayment thereof is now fixed at eighty years, and where in general money is borrowed for the purpose of providing allotments, it is not to be reckoned as part of the total outstanding debt of the Authority for the purpose of any enactment restricting such borrowing powers.

Powers of the Board to Let Land.

The Board are empowered to let land acquired by them for small holdings for use by the tenant as an allotment or to a Local Authority or Allotments Association for sub-letting for such use.

I am, Sir,
Your obedient Servant,
CHAS. WEATHERILL,
Secretary.

The following memorandum was issued with the foregoing letter:—

Allotments (Scotland) Acts, 1892 to 1922.

Procedure for the Assessment of Compensation and Powers of Arbiter where Land is acquired compulsorily.

The provisions of the Acquisition of Land (Assessment of Compensation) Act, 1919, apply generally where by or under any Statute (such as the Allotments Acts,) land is authorised to be acquired compulsorily by any Local Authority. Any question of disputed compensation or any question as to the apportionment of rent payable under a lease shall be determined by an official arbiter selected by the Reference Committee provided for in the Act.

Generally the official arbiter is required to act in accordance with the following rules [1] :—

"(1) No allowance shall be made on account of the acquisition being compulsory:

"(2) The value of land shall, subject as hereinafter provided, be taken to be the amount which the land, if sold in the open market by a willing seller, might be expected to realise: Provided always that the arbiter shall be entitled to consider all returns and assessments of capital value for taxation made or acquiesced in by the claimant:

"(3) The special suitability or adaptability of the land for any purpose shall not be taken into account if that purpose is a purpose to which it could be applied only in pursuance of statutory powers, or for which there is no market apart from the special needs of a particular purchaser or the requirements of any Government Department or any local or public authority: Provided that any *bona fide* offer for the purchase of the land made before the passing of this Act which may be brought to the notice of the arbiter shall be taken into consideration:

"(4) Where the value of the land is increased by reason of the use thereof or of any premises thereon in a manner which could be restrained by any court, or is contrary to law, or is detrimental to the health of the inmates of the premises or to the public health, the amount of that increase shall not be taken into account:

"(5) Where land is, and but for the compulsory acquisition would continue to be, devoted to a purpose of such a nature that there is no general demand or market for land for that purpose, the compensation may, if the official arbiter is satisfied that reinstatement in some other place is *bona fide* intended, be assessed on the basis of the reasonable cost of equivalent reinstatement:

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[1] *Vide* Section 2 of the Act.

"(6) The provisions of Rule (2) shall not affect the assessment of compensation for disturbance or any other matter not directly based on the value of land.

"An official arbiter shall be entitled to be furnished with such returns and assessments as he may require."

The costs of arbitration are in the discretion of the arbiter, but certain rules are laid down under which the arbiter is instructed to order the claimant to bear his own cost, and to pay the costs or part of the costs of the authority.

The Act permits, if the parties so agree, to the reference of any question as to disputed compensation or apportionment of rent to the Commissioners of Inland Revenue or to an arbiter mutually selected.

With regard to compulsory leasing under the Allotments (Scotland) Acts, 1892 to 1922, the provisions of the Acquisition of Land (Assessment of Compensation) Act, 1919, so far as applicable thereto, apply with the necessary modifications, and the following additional provisions are introduced by the Allotments (Scotland) Act, 1922[1]:—

(1) The official arbiter shall have power to determine any question—

(i) as to the terms and conditions of the proposed lease; or
(ii) as to the amount of compensation for severance; or
(iii) as to the compensation payable to any tenant in respect of the land taken forming part of any existing tenancy: or
(iv) as to the apportionment of the rent between the land acquired by the local authority and the land retained by the tenant; or
(v) as to any other matter incidental to the taking on lease of the land by the authority, or the surrender thereof at the end of their tenancy;

but the arbiter, in fixing the rent, shall not make any allowance in respect of the lease being compulsory.

(2) Any compensation awarded to a tenant in respect of any depreciation of the value to him of the residue of his holding caused by the withdrawal from the holding of the land taken on lease by the local authority shall, as far as possible, be provided for by taking such compensation into account in fixing, as the case may require, the rent to be paid by the authority for the land taken on lease by them, and the apportioned rent, if any, to be paid by the tenant for that portion of the holding which is not taken on lease by the authority. Provided always that during the unexpired period of the tenant's lease the sum *in cumulo* of the apportioned portions of rent shall not be less than the rent formerly paid by the tenant.

(3) The award of the arbiter or a copy thereof, together with a report signed by him as to the condition of the land taken on lease by the local authority, shall be deposited and preserved with the public books and papers of the authority, and any person interested shall, at all reasonable times, be at liberty to inspect the same, and to take copies thereof.

(4) The order[2] may incorporate or apply, with any adaptations which may be prescribed by the Board, such of the provisions of the Lands Clauses Acts (including those relating to the acquisitiou of land otherwise than by agreement) and of sections 70 to 78 of the Railways Clauses Consolidation (Scotland) Act, 1845, as appear to the Board sufficient for carrying into effect the order, and for the protection of the persons interested in the land, and of the local authority, and those Acts shall apply accordingly; but it shall not be necessary for the order to incorporate or apply any other provisions of those Acts.

Section 8 of the Allotments (Scotland) Act, 1922, provides that notwithstanding anything contained in any other enactment, counsel shall not be heard in any arbitration under the Allotments (Scotland) Acts, or as to compensation payable for land acquired for allotments under those Acts unless the Board of Agriculture for Scotland otherwise direct.

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[1] *Vide* Second Schedule of the Act.
[2] *i.e.*, Compulsory Order made by the Board.

STATISTICS.

PRICES of AGRICULTURAL PRODUCE and FEEDING STUFFS in September, October and November 1922.

AVERAGE PRICES OF LIVE STOCK IN SCOTLAND.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	September.			October.			November.		
	1st.	2nd.	3rd.	1st.	2nd.	3rd.	1st.	2nd	3rd.
FAT STOCK :—									
CATTLE—	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.
Aberdeen-Angus .	76 0	67 9	44 5	73 1	64 8	42 1	75 8	67 3	43 3
Shorthorn	...	...	...	.	...	...	...	..	...
Galloway	67 0	59 6	...	64 2	55 6	...	65 2	56 8	...
Ayrshire	63 0	55 6	36 0	63 0	53 6	40 0	64 0	51 2	36 0
Cross-bred	70 9	62 6	43 4	68 8	60 2	40 6	70 7	62 4	41 3
Blue Grey	83 6	...	...	...	...	..	...	...	...
Highland	66 11	...	...	...	...	.	...	...	...
	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
VEAL CALVES	11½	6¼	4½	10½	7¼	4½	10¼	7¾	5
SHEEP—	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds per lb. d.	Ewes per lb. d.
Cheviot	15½	14¾	12¼	15¼	14½	11¾	16	15¼	12¼
Half-bred	16½	15¾	10¾	16	14½	10½	16¼	15	11½
Blackface	16¼	14¾	12¼	16	14¼	12	16¼	15	12
Greyface	16¾	15¾	10¼	16½	15½	10½	16¾	15¼	10¾
Down Crosses ..	16½	16	12	16	15	...	16	15¼	...
PIGS—	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.
Bacon Pigs	14 10	13 4	10 10	15 0	13 4	10 6	14 10	13 3	10 3
Porkers	15 1	13 10	11 2	15 2	13 10	11 0	15 0	13 8	10 6

AVERAGE PRICES OF LIVE STOCK IN SCOTLAND—*continued.*

Description.	September.			October.			November.		
	1st.	2nd.	3rd.	1st.	2nd.	3rd.	1st.	2nd.	3rd.
STORE STOCK :—									
STORE CATTLE—									
	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.
Aberdeen-Angus :									
Yearlings	22 8	17 13	11 3	19 10	15 14	11 13	20 0	15 16	9 15
Two-year-olds ...	31 8	25 9	16 10	28 14	22 5	18 10	29 10	24 3	18 5
Shorthorn :									
Yearlings	...	...	...	23 0	18 0	12 10	...	...	..
Two-year-olds ...	...	...	...	32 5	26 15	21 10	...	...	...
Galloway:									
Yearlings	15 5	...	...	16 0	...	...	14 13	...	...
Two-year-olds ...	31 10	21 10	...	29 8	21 0	...	22 10	20 3	...
Ayrshire :									
Yearlings	10 15	...	...	11 7	10 5	...	7 0	...	..
Two-year-olds ...	...	...	...	18 10	14 15	...	...	...	...
Cross-bred :									
Yearlings	17 17	15 0	12 2	17 19	14 16	10 13	17 9	14 7	11 15
Two-year-olds ...	27 7	23 3	18 10	27 17	22 9	17 9	26 16	22 6	17 0
Blue Grey :									
Yearlings	...	...	...	18 15	...	...	...	...	...
Two-year-olds ...	...	...	..	...	...	...	...	...	...
Highland :									
Yearlings	9 16	7 15	5 5	10 11	8 3	5 19	9 5	7 1	4 16
Two-year-olds ...	15 0	12 14	10 4	16 10	13 1	11 6	14 3	11 8	8 15
Three-year-olds ...	22 7	19 18	...	22 12	19 8	18 13	20 19	19 0	15 5
DAIRY COWS—									
Ayrshire :									
In Milk	36 3	24 15	16 18	35 11	22 17	14 5	35 4	23 16	14 0
Calvers	37 1	25 8	15 16	35 5	25 3	16 5	37 3	26 6	16 9
Shorthorn Crosses :									
In Milk	41 14	29 10	23 0	41 12	30 6	25 15	40 5	29 0	24 18
Calvers	39 14	26 16	18 5	39 8	27 2	18 7	39 7	28 5	19 18
STORE SHEEP—									
	s. d.	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*	*s. d.*
Cheviot Hoggs ...	64 3	51 0	...	66 8	47 1	41 9	54 6	44 0	42 9
Half-bred Hoggs ...	114 3	93 5	...	67 0	...	...	60 11	49 2	35 0
Blackface Hoggs ...	45 11	35 7	26 0	53 10	41 4	33 2	46 11	36 10	32 8
Greyface Hoggs ...	68 5	55 6	...	69 6	49 7	28 0	37 0	...	...
STORE PIGS—									
(6 to 10 weeks old)	46 6	32 6	...	50 1	34 0	...	46 7	31 6	...

AVERAGE PRICES OF DEAD MEAT AT DUNDEE, EDINBURGH, AND GLASGOW.

(*Compiled from Reports received from the Board's Market Reporters.*)

Description.	Quality.	September.			October.			November.		
		Dundee.	Edinburgh.	Glasgow.	Dundee.	Edinburgh.	Glasgow.	Dundee.	Edinburgh.	Glasgow.
		per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d*	per lb. *d.*	per lb. *d.*
BEEF :—										
Home-fed—										
Bullock or Heifer ..	1	10½	11⅜	12⅞	10⅛	10⅝	13⅛	10½	10	13
	2	10⅛	10	10⅝	9⅝	9⅛	10½	10	8¾	10¼
Bull	1	9⅛	9¼	9¼	8½	8⅝	8½	8⅝	8	8½
	2	8⅝	8⅜	8¼	8	8	7½	8⅛	7¼	7½
Cow	1	7⅞	7½	8	7⅛	7	8¼	7	6¾	7¾
	2	7	7	6⅜	6¼	6⅛	6⅜	6	5¾	5⅞
Irish—										
Bullock or Heifer ...	1	...	...	10¼	...	...	9⅝	9¼	...	9½
	2	...	...	8⅝	...	...	8	9	...	8
Bull	1	...	...	8½	...	...	8	...	...	7⅜
	2	...	...	7	...	...	6½	...	...	6⅛
United States and Canadian—										
Killed at Birkenhead	1	...	...	...	...	...	9	...	...	9
	2	...	...	...	...	...	8½	...	...	8¼
Argentine Frozen—										
Hind Quarters ...	1	...	6¼	6½	...	6¾	6⅛	...	5⅞	5⅞
Fore ,, ...	1	...	4	4	...	4	4	...	4¼	4
Argentine Chilled—										
Hind Quarters ...	1	...	8¼	7⅞	...	6¾	6⅞	...	7	6⅝
Fore ,, ...	1	...	4¼	4½	...	4⅛	4	...	4⅝	4½
	2	...	...	4	...	..	3¾	...	...	4⅛
Australian Frozen—										
Hind Quarters ...	1	...	5½	5⅝	...	5¾	5¾	...	5½	5¾
	2	...	...	5¼	...	...	5⅜	...	...	5½
Fore ,, ...	1	...	...	4	...	4	4	..	4	4
	2	...	...	...	...	...	...	...	...	3½
MUTTON :—										
Hoggs, Blackface ...	under 60 lb.	17½	14⅜	15¾	16	14¼	15⅜	15¾	14	15½
	60 lb. and over.	...	13⅞	14½	15½	13½	14⅛	15	13¼	14¾
,, Cross	under 60 lb.	17½	15	15¾	16	14⅝	15⅜	15¾	14½	15½
	60 lb. and over.	...	14¼	14½	15½	13¾	14	15	13¼	14½
Ewes, Cheviot ...	1	10¼	9½	11	10½	9¼	10⅜	10½	9⅜	10¼
	2	10	...	9⅜	...	...	9⅜	10	...	9⅜
,, Blackface ...	1	10¼	...	10½	10½	...	10⅜	10½	...	10⅛
	2	10	...	8⅛	...	...	7⅞	10	...	8⅞
,, Cross	1	8¼	8⅛	9	8	8½	8⅝	8⅝	8⅝	8⅞
	2	8	...	8⅛	...	...	7⅞	8	...	7⅜
Argentine Frozen ...	1	...	6¾	6⅝	...	7⅛	7	...	7¾	7⅝
	2	...	...	6	...	...	...	...	..	..
Australian ,, ...	1	...	5¾	6⅜	...	...	6¾	...	7½	7⅜
	2	...	..	6½	...	...	6½	...	...	...
New Zealand ,, ...	1	...	...	...	...	...	...	...	...	7⅛
LAMB :—										
Home-fed	1	17¾	15	15¾	16	15⅛	15¾	15¾	15⅛	15½
	2	...	12⅝	13	...	13¾	12	...	13⅜	13⅜
New Zealand Frozen	1	...	11¾	11⅝	...	12⅛	12	...	12⅞	13
Australian ,, ..	1	...	...	11⅝	...	...	...	...	...	11¾
Argentine ,, ...	1	...	10	10	..	9¾	10¼	...	10	...
	2	...	...	9¼	...	...	...	...	...	...

Average Prices of Provisions at Glasgow.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	Quality.	Sept. s.	Sept. d.	Oct. s.	Oct. d.	Nov. s.	Nov. d.
Butter:							
Irish Creamery... per cwt.	1	209	0	214	6	213	2
„ „ (Unsalted) „	1	219	6	226	0	223	2
Danish ... ... „	1	223	9	229	6	221	7
„ (Unsalted) „	1	234	0	239	6	230	10
New Zealand ... ... „	1	222	6	227	9	220	0
Cheese:							
Cheddar ... ... „	1	95	6	104	0	132	5
	2	91	6	101	0	128	5
Cheddar Loaf ... ... „	1	106	0	...		144	0
Dunlop ... ... „	1	87	6	97	6	124	5
	2	84	0	94	0	120	0
Canadian ... ... „	1	96	6	104	6	131	2
	2	94	0	102	6	...	
New Zealand ... ... „	1	94	6	105	6	...	
New Zealand (White) „	1	97	6	105	6	...	
	2	94	6	100	0	...	
Bacon:							
Ayrshire (Rolled) ... „	1	192	6	186	6	185	5
Irish (Green) ... ... „	1	162	3	154	6	155	2
„ (Dried or Smoked) „	1	191	0	171	6	172	0
„ (Long Clear) ... „	1	170	0	162	6	166	5
Wiltshire (Green) ... „	1	162	3	154	6	155	2
„ (Dried or Smoked) „	1	191	0	171	0	172	0
American, Long Clear Middles (Green) „	1	119	0	119	0	119	0
American, Short Clear Backs ... ... „	1	103	9	108	0	110	0
American Bellies ... „	1	86	0	86	0	86	0
„ Sides ... „	1	118	0	116	0	113	2
	2	102	0	107	0	111	2
„ Cumberland Cut „	1	111	6	113	6	110	10
	2	107	6	108	0	107	5
Canadian, Sides ... „	1	140	0	129	6	120	0
Danish, Sides ... „	1	156	6	142	9	136	10

Description.	Quality.	Sept. s.	Sept. d.	Oct. s.	Oct. d.	Nov. s.	Nov. d.
Hams:							
Irish (Smoked) per cwt.	1	211	6	196	0	179	2
	2	206	6	192	0	...	
American, Long Cut (Green) .. ... „	1	106	0	102	0	99	7
American, Short Cut „	1	104	6	104	0	98	10
	2	102	6	102	0	97	0
Canadian, Long Cut „	1	...		...		...	
Eggs:							
Country ... ... per doz.	1	2	9	3	5	4	0
	2	2	7	3	3	3	10
Irish ... ... per 120	1	21	2	25	11	30	0
	2	19	8	24	11	28	6
„ (Cold Stored) „	1	...		21	0	21	9
	2	...		20	0	20	0
„ (Pickled) ... „	1	...		17	6	16	10
„ (Duck) ... „	1	18	5	22	6	26	1
American ... ... „	1	16	9	19	11	18	2
	2	...		19	0	17	8
Argentine ... ... „	1	...		...		21	8
	2	...		...		20	6
Canadian ... ... „	1	...		21	6	21	9
	2	...		20	0	20	8
Chinese ... ... „	1	12	3	13	9	14	4
	2	12	0	13	0	...	
Danish ... ... „	1	23	3	26	3	31	11
	2	21	6	25	3	29	6
„ (Pickled) ... „	1	...		18	0	18	5
	2	...		...		18	0
Polish ... ... „	1	13	4	16	8	17	1
	2	...		16	6	16	6
Pomeranian ... „	1	16	0	17	3	17	9
	2	15	6	...		...	

Average Prices of Potatoes at Dundee, Edinburgh, and Glasgow.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Second Earlies.	Late Varieties. Red Soils. Langworthy.	Late Varieties. Red Soils. Other.	Late Varieties. Other Soils. Langworthy.	Late Varieties. Other Soils. Other.
		per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
		SEPTEMBER.				
Dundee	First ...	3 0 0	...	...	...	...
	Second ...	...	...	...	...	...
Edinburgh	First ...	3 8 9	...	...	...	...
	Second ...	...	...	...	...	...
Glasgow	First ...	3 17 6	...	...	...	...
	Second ...	...	...	...	...	...
		OCTOBER.				
Dundee	First ...	3 0 0	...	...	...	...
	Second ...	...	...	...	...	...
Edinburgh	First ...	3 5 0	...	...	...	3 5 0
	Second ...	...	...	...	...	...
Glasgow	First ...	3 9 3	...	...	...	...
	Second ...	...	...	...	...	...
		NOVEMBER.				
Dundee	First ...	2 19 0	...	...	...	...
	Second ...	...	...	...	...	...
Edinburgh	First ...	3 8 4	5 10 0	5 6 8	...	3 9 0
	Second ...	...	...	...	...	...
Glasgow	First ...	3 0 0	...	5 13 4	...	3 4 8
	Second ...	...	...	...	...	...

Average Prices of Roots, Hay, Straw, and Moss Litter, at Dundee, Edinburgh, and Glasgow.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Roots: Carrots.	Roots: Yellow Turnips.	Roots: Swedes.	Hay: Rye Grass and Clover.	Hay: Timothy.	Straw: Wheat.	Straw: Barley.	Straw: Oat.	Moss Litter.
		per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.
SEPTEMBER.										
Dundee ...	1	...	25 6	...	132 6*	...	106 3*	...	98 2*	...
	2	...	...	...	120 0*	...	100 0*	...	...	...
Edinburgh	1	...	...	...	111 11†	...	81 8†	59 2†	75 0†	...
	2	...	...	...	...	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6
OCTOBER.										
Dundee ...	1	...	20 0	...	135 0*	...	97 6*	...	98 9*	...
	2	...	...	...	117 6*	...	...	...	...	...
Edinburgh	1	...	...	...	114 5†	...	71 3†	58 9†	66 11†	...
	2	...	...	...	80 0†	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6
NOVEMBER.										
Dundee ...	1	...	20 2	...	132 0*	...	94 0*	...	96 0*	...
	2	...	...	...	120 0*	...	...	...	...	...
Edinburgh	1	...	...	...	110 0†	...	66 0†	53 0†	65 0†	...
	2	...	...	...	74 6†	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 11

* Price for Hay and Straw baled and delivered.

† Price for Hay and Straw delivered loose in town.

AVERAGE PRICES OF FEEDING STUFFS AT GLASGOW AND LEITH.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	SEPTEMBER.		OCTOBER.		NOVEMBER	
	Glasgow.	Leith.	Glasgow.	Leith.	Glasgow.	Leith.
	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
Linseed Cake—						
Home	14 0 0	13 9 0	13 15 0	13 2 6	14 7 0	13 14 0
Foreign	13 10 0	...	13 1 3	...	13 13 9	...
Undecorticated Cotton Cake—						
Bombay (Home-manufactured)	7 11 3	7 1 11	7 10 0	7 0 0	7 19 0	7 4 6
Egyptian (Home-manufactured)	8 15 0	...	8 3 9	...	8 9 0	...
Groundnut Cake—						
Decorticated ...	12 10 0	...	12 7 6	...	12 10 0	...
Undecorticated ...	...	10 7 6	...	10 7 6	...	10 12 6
Palmnut Kernel Cake	...	...	8 0 0	...	...	...
Bean Meal ...	13 0 0	12 15 0	13 15 0	12 12 6	13 15 0	13 10 0
Maize	*8 11 3	8 6 3	*9 11 3	8 16 11	*9 16 0	9 7 6
Maize Meal ...	9 7 6	9 2 6	10 0 0	9 15 8	10 0 0	10 7 6
Maize Gluten Feed (Paisley)	9 0 0	...	9 2 6	...	9 10 0	...
Maize Germ Cake Meal	11 10 0	...	12 5 0	...	11 18 6	...
Rice Meal... ...	8 0 0	...	...	...	...	...
Locust Bean Meal	...	8 7 6	...	8 7 6	...	7 8 0
Maize Germ Cake	11 0 0	...	11 12 6	...	11 8 6	...
Barley (Feeding) ...	9 16 8	...	9 17 6	10 0 0	10 0 0	10 0 0
Oats, American ...	9 2 6	...	9 12 6	...	9 3 6	...
„ Home ...	10 6 8	8 16 11	9 15 0	9 6 3	9 16 0	9 5 0
Malt Culms ...	6 2 6	...	6 15 0	...	6 12 0	...
Distillery Malt Grains—Dried ...	8 10 0	...	8 6 0	...	8 12 6	...
Distillery Mixed Grains—Dried ...	9 0 0	8 13 9	8 13 9	8 15 0	8 17 6	8 15 0
„ Wet ...	...	1 15 0	...	1 15 0	...	1 15 0
Brewers' Grains—						
Dried	8 11 8	8 0 0	8 6 3	8 0 0	8 5 10	8 0 0
Wet	...	1 15 0	...	1 15 0	...	1 15 0
Wheat—						
Middlings (Fine Thirds or Parings)	10 10 0	9 17 6	9 8 9	9 6 3	8 12 0	9 3 0
Sharps (Common Thirds)	8 1 3	8 0 0	7 8 9	7 8 9	7 10 0	7 12 0
Bran (Medium) ...	7 2 6	7 5 0	7 5 0	6 17 6	7 10 0	7 7 0
„ (Broad) ...	7 15 0	...	7 15 0	...	7 15 0	...
Feeding Treacle ...	5 18 9	5 15 0	5 10 0	5 15 0	5 7 6	5 8 4
Crushed Linseed ...	...	...	...	...	...	...
Fish Meal... ...	15 0 0	15 0 0	14 17 6	15 0 0	14 14 0	15 8 0

* American Corn.

ACREAGE UNDER EACH VARIETY OF POTATOES IN SCOTLAND IN 1922, AS RETURNED BY GROWERS OF ONE ACRE AND OVER.

Variety.	Acres.
***A.* First Earlies.**	
1. America	78
2. Arran Rose	110
3. Dargill Early	167
4. Immune Ashleaf *	67
5. Snowdrop (including Witch Hill)	164
6. Beauty of Hebron (including Puritan)	135
7. Duke of York (including Midlothian Early and Victory)	1,762
8. Early Rose	29
9. Eclipse (including Sir John Llewelyn)	1,947
10. Epicure	10,322
11. May Queen	141
12. Myatt's Ashleaf Kidney	30
13. Ninetyfold	130
14. Sharpe's Express	1,070
15. Sharpe's Victor	129
16. Other First Earlies not specified above	214
Total First Earlies	16,495
***B.* Second Earlies.**	
17. Ally	915
18. Arran Comrade	3,939
19. Conquest (including Duchess)	28
20. Edzell Blue	314
21. Great Scot	11,368
22. Katie Glover	59
23. King George V.	1,368
24. K. of K.	120
25. Nithsdale	100
26. British Queen (including Pioneer, Macpherson, Maid of Auchterarder, Scottish Standard, English Beauty, etc.)	5,803
27. Royal Kidney (including Queen Mary)	214
28. Windsor Castle	21
29. Other Second Earlies not specified above	681
Total Second Earlies	24,930

Variety.	Acres.
***C.* Maincrops.**	
30. Abundance (including Admiral, Balmuir, Bloomfield, Culdees Castle, Kerr's New White, Laing's Prolific, Lomond, Twentieth Century, etc.)	2,329
31. Arran Victory	962
32. Bishop	230
33. Burnhouse Beauty	27
34. Champion	2,290
35. Crusader	1,580
36. Dean (Dr. Wilson) *	57
37. Dominion	16
38. Early Market *	95
39. Golden Wonder (including Peacemaker)	7,862
40. Irish Chieftain *	52
41. Irish Queen	180
42. Kerr's Pink	11,326
43. Langworthy (including Maincrop and What's Wanted)	2,642
44. Lochar	1,174
45. Majestic	2,773
46. Rhoderick Dhu	330
47. Templar	311
48. Tinwald Perfection	5,125
49. White City (including Carnegie)	84
50. Arran Chief	29,493
51. Beauty of Bute (including John Bull) *	94
52. Evergood	736
53. Field-Marshal *	243
54. General *	227
55. King Edward VII.	20,276
56. Northern Star (including Ajax, Allies, and Aeroplanes)	443
57. President (including Iron Duke and Scottish Farmer)	996
58. Up-to-Date (including Dalhousie, Factor, Glamis Beauty, Scottish Triumph, Stephen, Table Talk, etc.)	4,598
59. Other Maincrops not specified above	1,538
Total Maincrops	98,089

TOTAL AREA RETURNED ... 139,514

NOTES.—(1) The Varieties marked * were not returned separately in 1921.

(2) The following Varieties were returned separately in 1921, but are this year included as "not specified":—"Resistant Snowdrop" (First Early) and "Rector" (Maincrops).

(3) In the county of Inverness the districts of Skye, Harris, North and South Uist were excluded. In the county of Ross the Western and South-Western districts and the district of Lewis were excluded.

ABSTRACT OF AGRICULTURAL RETURNS FOR SCOTLAND, 1922.

Collected 3rd June, 1922 (and comparison with 1921).

CROPS.

Distribution.	1922.	1921.	Increase.		Decrease.	
	Acres.	*Acres.*	*Acres.*	*Per Cent.*	*Acres.*	*Per Cent.*
Total Area (excluding Water)	19,069,683	19,069,683	.	..	..	..
Total Acreage under all Crops and Grass (*a*)	4,725,499	4,729,604	..	.	4,105	0·09
Arable Land	3,338,068	3,349,067	..	..	10,999	0·33
Permanent Grass (*a*) — For Hay	144,804	142,964	1,840	1·29	..	..
Permanent Grass (*a*) — Not for Hay .	1,242,627	1,237,573	5,054	0·41	..	.
Permanent Grass (*a*) — Total.. .	1,387,431	1,380,537	6,894	0·50	..	..
Wheat	65,251	65,191	60	0·09	..	..
Barley (including Bere)	157,020	170,721	..	..	13,701	8·03
Oats	988,392	1,011,615	..	..	23,223	2·30
Mixed Grain	1,036	704	332	47·16	.	..
Rye..	6,694	6,201	493	7·95	..	.
Beans (to be harvested as Corn)	3,692	1,704	..	..	1,012	21·51
Peas	460	399	61	15·29	..	..
Potatoes	157,404	153,820	3,584	2·33	..	
Turnips and Swedes	404,112	410,789		..	6,677	1·63
Mangolds	2,008	1,771	237	13·38	..	..
Cabbage	3,788	3,587	201	5·60	.	
Rape	11,132	16,717		..	5,585	33·41
Vetches or Tares, for Seed	354	301	53	17·61	..	.
Vetches, Tares, Beans, Peas, Mashlum, etc., for Fodder	9,564	10,066	.	..	502	4·99
Carrots	511	298	213	71·48	..	.
Onions	177	137	40	29·20	.	.
Flax	290	452			162	35·84
Small Fruit	6,758	6,304	454	7·20	.	..
Rye-grass and other Rotation Grasses and Clover — For Hay ..	431,601	410,556	21,045	5·13	.	.
Rye-grass and other Rotation Grasses and Clover — Not for Hay .	1,079,409	1,066,066	13,343	1·25		.
Rye-grass and other Rotation Grasses and Clover — Total ..	1,511,010	1,476,622	34,388	2·33	..	..
Other Crops	2,023	1,758	265	15·07	..	..
Bare Fallow	6,392	6,910		..	518	7·50
Orchards (*b*)	1,536	1,583	.		47	2·97

LIVE STOCK.

	1922.	1921.	Increase.		Decrease.	
	No.	*No.*	*No.*	*Per Cent.*	*No.*	*Per Cent.*
Horses used for Agricultural purposes (including Mares for Breeding)	189,411	189,217	194	0·14	..	..
Unbroken Horses (including Stallions) — One year and above	39,626	40,119	.	..	493	1·23
Unbroken Horses (including Stallions) — Under one year ..	9,814	12,677	..	..	2,863	22·58
Total	188,851	192,013	.	..	3,162	1·65
Other Horses	22,918	24,608	.	..	1,690	6·87
Total of Horses . ..	211,769	216,621	..	..	4,852	2·24
Cows in Milk	358,943	346,495	12,448	3·59		..
Cows in Calf, but not in Milk	44,695	41,724	2,971	7·12	.	
Heifers in Calf	48,593	54,829	..	..	6,236	11·37
Bulls being used for Service	18,386	18,463	..	..	77	0·42
Other Cattle :—Two years and above ..	199,242	228,173	..	..	28,931	12·68
,, ,, One year and under two ..	250,157	232,262	17,895	7·70	..	..
,, ,, Under one year	226,791	221,189	5,602	2·53	..	..
Total of Cattle	1,146,807	1,143,135	3,672	0·32	..	..
Ewes kept for Breeding	2,872,529	2,814,812	57,717	2·05	..	..
Rams to be used for Service in 1922	79,763	80,070	..	..	307	0·38
Other Sheep :—One year and above.. ..	971,618	1,029,714	..	..	58,096	5·64
,, ,, Under one year	2,760,187	2,733,915	26,272	0·96	..	..
Total of Sheep	6,684,097	6,658,511	25,586	0·38	..	..
Sows kept for Breeding	18,407	17,962	445	2·48	..	..
Boars being used for Service	2,151	1,927	224	11·62	..	..
Other Pigs	130,326	125,609	4,717	3·76	..	..
Total of Pigs	150,884	145,498	5,386	3·70	..	..

(*a*) Excluding Mountain and Heath Land used for grazing (9,634,271 acres in 1922).
(*b*) Any Crop or Grass grown in Orchards is also returned under its proper heading.

ACREAGE under WHEAT, BARLEY (including Bere), and OATS in each COUNTY on 3rd June 1922, with COMPARISON for 1921.

COUNTIES.	Wheat.		Barley (including Bere).		Oats.	
	1922.	1921.	1922.	1921.	1922.	1921.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
ABERDEEN	54	38	21,414	23,392	190,641	191,763
ARGYLL	2	...	1,152	1,292	17,205	17,177
AYR	983	1,418	344	452	42,929	45,639
BANFF	3	1	7,864	8,494	48,915	48,651
BERWICK	3,053	3,627	16,296	17,715	30,481	31,516
BUTE	7	4	7	7	5,056	5,172
CAITHNESS	..	...	650	749	31,330	31,275
CLACKMANNAN	432	428	176	236	3,175	3,328
DUMBARTON	662	839	16	35	7,658	7,999
DUMFRIES	96	124	292	437	41,194	42,769
EAST LOTHIAN	6,272	6,365	14,037	14,743	17,716	17,891
FIFE	13,786	13,461	13,518	15,089	44,955	46,921
FORFAR	11,119	10,480	18,696	19,189	56,080	57,747
INVERNESS	48	89	5,077	5,775	31,026	30,084
KINCARDINE	1,482	1,105	9,567	10,485	30,555	31,622
KINROSS	219	297	154	237	7,264	7,882
KIRKCUDBRIGHT	18	3	39	35	24,900	26,340
LANARK	2,459	2,902	134	140	40,475	42,254
LINLITHGOW	2,938	2,656	1,841	2,160	11,375	11,800
MIDLOTHIAN	6,722	6,227	4,653	5,519	21,818	22,152
MORAY	785	811	9,696	10,167	24,692	24,591
NAIRN	18	13	2,330	2,458	6,224	6,380
ORKNEY	...	...	3,510	3,739	34,496	34,469
PEEBLES	8	6	310	336	6,923	7,056
PERTH	8,313	8,182	3,973	4,926	73,412	76,586
RENFREW	1,952	2,155	9	21	10,649	11,536
ROSS & CROMARTY	753	999	8,935	8,944	31,388	32,628
ROXBURGH	767	583	9,581	10,595	26,929	27,728
SELKIRK	15	26	338	372	4,135	4,141
SHETLAND	...	...	726	806	6,740	6,567
STIRLING	2,194	2,181	1,024	1,358	19,169	20,211
SUTHERLAND	...	...	448	506	8,142	7,722
WIGTOWN	91	171	213	312	30,745	32,018
TOTAL	65,251	65,191	157,020	170,721	988,392	1,011,615

ACREAGE under BEANS, POTATOES, and TURNIPS and SWEDES in each COUNTY on 3rd June 1922, with COMPARISON for 1921.

COUNTIES.	Beans.*		Potatoes.		Turnips and Swedes.	
	1922.	1921.	1922.	1921.	1922.	1921.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
ABERDEEN .	17	8	8,049	7,635	81,748	82,633
ARGYLL . .	22	30	3,265	3,443	5,372	5,390
AYR . .	288	270	9,895	9,853	7,368	7,529
BANFF . .	29	34	1,848	1,903	20,106	20,202
BERWICK. .	263	458	2,983	2,714	21,466	22,347
BUTE . .	19	23	1,166	1,159	1,335	1,300
CAITHNESS .	...	...	1,360	1,417	11,515	11,385
CLACKMANNAN	219	256	449	467	781	758
DUMBARTON .	28	28	2,762	2,741	1,393	1,398
DUMFRIES .	...	13	4,292	4,534	15,091	15,399
EAST LOTHIAN	61	137	8,228	7,774	12,660	12,906
FIFE . .	243	446	18,565	17,679	20,968	21,260
FORFAR . .	18	64	19,564	18,479	29,741	30,816
INVERNESS .	...	3	5,298	5,464	9,297	9,364
KINCARDINE .	31	27	5,136	4,528	15,263	15,610
KINROSS . .	3	1	1,449	1,328	2,324	2,452
KIRKCUDBRIGHT	2	7	1,589	1,795	10,165	10,213
LANARK . .	16	62	6,237	6,426	9,429	9,434
LINLITHGOW .	29	11	2,699	2.601	3,262	3,185
MIDLOTHIAN .	3	24	7,248	6,975	9,631	9,462
MORAY . .	20	13	1,717	1,697	13,652	13,841
NAIRN . .	1	...	278	277	3,765	3,780
ORKNEY . .	...	...	2,331	2,396	13,632	13,733
PEEBLES . .	..	...	417	461	3,124	3,209
PERTH . .	730	824	19,865	19,605	24,348	25,071
RENFREW .	55	92	3,464	3,283	2,125	2,130
ROSS AND CROMARTY .	...	1	7,067	6,800	14,233	14,323
ROXBURGH .	88	137	1,275	1,280	17,680	18,564
SELKIRK . .	...	...	176	181	2,145	2,275
SHETLAND .	...	...	2,253	2,279	1,008	1,029
STIRLING. .	1,441	1,634	3,555	3,589	3,932	3,862
SUTHERLAND .	...	...	1,208	1,283	2,826	2,797
WIGTOWN .	66	101	1,716	1,774	12,727	13,132
TOTAL .	3,692	4,704	157,404	153,820	404,112	410,789

* To be harvested as corn.

ACREAGE under RYE-GRASS and other ROTATION GRASSES and CLOVER, and under PERMANENT GRASS in each COUNTY on 3rd June 1922, with COMPARISON for 1921.

COUNTIES.	Rye-grass and other Rotation Grasses and Clover.				Permanent Grass.			
	For Hay.		Not for Hay.		For Hay.		Not for Hay.	
	1922.	1921.	1922.	1921.	1922.	1921.	1922.	1921.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres*	*Acres.*
ABERDEEN	54,459	50,767	234,985	235,247	724	841	31,530	31,625
ARGYLL	12,405	12,266	15,338	16,094	14,199	14,471	57,936	57,458
AYR	28,704	26,537	51,681	51,374	20,765	20,722	147,854	147,270
BANFF	10,807	10,474	57,354	57,977	283	314	9,797	9,806
BERWICK	12,257	11,166	47,089	48,187	2,154	1,686	52,053	48,677
BUTE	2,614	2,396	6,080	6,060	403	399	8,542	8,626
CAITHNESS	10,130	10,279	25,621	25,787	603	805	25,357	25,178
CLACKMANNAN	1,525	1,519	1,845	1,615	944	1,029	5,598	5,526
DUMBARTON	5,827	5,526	5,881	5,665	1,697	1,910	20,500	20,536
DUMFRIES	21,158	19,266	48,357	49,041	18,381	17,482	95,090	95,250
EAST LOTHIAN	10,026	9,770	16,390	16,529	717	447	20,918	20,929
FIFE	27,805	27,073	31,412	29,141	3,209	2,673	65,305	66,069
FORFAR	24,423	23,095	59,173	60,098	1,224	1,168	23,174	22,499
INVERNESS	11,714	11,722	21,145	19,887	7,301	7,899	55,808	56,214
KINCARDINE	14,053	13,701	32,411	32,984	215	167	8,854	7,577
KINROSS	3,576	3,180	7,379	6,333	721	677	10,093	10,674
KIRKCUDBRIGHT	10,886	10,661	51,592	46,002	11,726	11,262	69,405	71,633
LANARK	34,148	31,773	37,063	35,353	11,331	12,501	102,109	101,634
LINLITHGOW	7,202	7,154	5,383	5,557	980	1,016	20,696	20,401
MIDLOTHIAN	11,839	11,500	15,839	15,747	2,007	1,755	38,610	39,451
MORAY	5,908	5,935	33,970	33,016	265	146	6,857	7,517
NAIRN	1,966	1,983	9,166	8,764	30	22	1,781	1,908
ORKNEY	9,603	10,449	29,616	28,480	488	359	13,776	14,026
PEEBLES	2,587	2,482	11,363	11,892	1,271	1,454	23,764	22,687
PERTH	36,682	33,595	61,634	59,737	10,511	10,590	80,207	80,290
RENFREW	9,844	9,099	7,235	6,859	6,335	6,016	41,990	42,547
ROSS AND CROMARTY	13,688	14,015	33,293	32,082	2,432	2,562	23,783	23,232
ROXBURGH	10,033	8,924	46,165	45,138	6,937	6,470	55,890	55,856
SELKIRK	1,393	1,165	6,728	6,954	1,796	1,734	13,087	12,708
SHETLAND	1,284	1,416	671	585	1,725	1,691	11,172	10,498
STIRLING	12,076	11,398	9,552	10,274	7,121	6,804	50,794	49,697
SUTHERLAND	4,531	4,485	5,699	5,165	1,410	1,486	6,169	6,529
WIGTOWN	6,448	5,785	52,319	52,442	4,899	4,406	44,128	43,045
TOTAL	431,601	410,556	1,079,409	1,066,066	144,804	142,964	1,242,627	1,237,573

NUMBER of HORSES, CATTLE, SHEEP, and PIGS in each COUNTY on 3rd June 1922, with COMPARISON for 1921.

COUNTIES.	Horses.†		Cattle.		Sheep.		Pigs.	
	1922.	1921.	1922.	1921.	1922.	1921.	1922.	1921.
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
ABERDEEN .	29,524	30,594	165,316	167,420	203,484	191,986	15,401	14,873
ARGYLL . .	6,199	6,371	56,412	56,578	755,842	780,551	4,274	4,505
AYR . .	10,070	10,227	111,784	111,295	348,994	349,634	12,388	11,422
BANFF . .	8,776	8,806	43,665	43,669	61,965	57,667	3,734	3,747
BERWICK . .	4,528	4,674	15,703	15,167	317,245	318,192	4,968	4,320
BUTE . .	1,333	1,354	9,630	9,590	38,597	39,476	671	735
CAITHNESS .	5,631	5,685	20,127	19,525	147,513	134,611	2,390	1,869
CLACKMANNAN	802	754	3,422	3,139	12,783	14,732	645	547
DUMBARTON .	1,886	1,859	13,632	13,405	65,799	66,230	1,112	1,208
DUMFRIES .	7,570	7,567	67,725	64,907	539,879	540,116	9,004	9,731
EAST LOTHIAN	3,361	3,515	8,579	10,404	123,557	124,194	3,125	2,410
FIFE . .	9,487	9,846	38,089	40,457	91,978	90,330	8,205	7,471
FORFAR . .	8,916	9,171	40,204	44,250	165,927	156,949	6,916	7,425
INVERNESS .	8,183	8,308	47,147	44,766	496,201	500,268	1,829	1,873
KINCARDINE .	4,792	5,019	22,641	24,803	39,348	39,092	2,507	2,636
KINROSS . .	1,274	1,289	5,520	5,394	29,079	27,162	725	763
KIRKCUDBRIGHT	5,383	5,239	55,721	53,600	363,356	362,305	11,825	11,048
LANARK . .	8,334	8,410	72,115	70,116	225,934	225,745	7,005	7,687
LINLITHGOW .	2,250	2,226	11,350	10,795	14,012	14,302	1,732	1,523
MIDLOTHIAN .	3,853	3,891	16,029	15,687	170,632	170,100	11,477	10,216
MORAY . .	4,911	5,027	21,267	22,074	44,754	43,872	2,232	2,292
NAIRN . .	1,370	1,346	6,079	5,907	13,744	13,517	877	851
ORKNEY . .	6,562	6,608	31,307	30,270	34,113	31,907	1,841	1,883
PEEBLES . .	1,048	1,104	6,588	6,509	200,738	201,141	423	487
PERTH . .	12,739	13,050	61,806	61,351	582,841	572,534	8,566	8,979
RENFREW .	2,942	3,062	25,483	25,797	36,796	37,517	2,981	2,904
ROSS AND CROMARTY .	6,754	6,892	38,438	38,265	265,111	269,369	3,433	3,197
ROXBURGH .	3,897	3,903	18,630	17,863	526,252	518,722	3,239	3,316
SELKIRK . .	582	613	3,327	3,089	183,055	182,187	600	665
SHETLAND .	3,029	2,876	13,583	13,511	152,901	152,360	531	569
STIRLING .	4,649	4,818	30,435	30,086	114,195	114,386	2,390	2,559
SUTHERLAND .	2,252	2,168	10,451	9,741	200,960	205,566	731	587
WIGTOWN .	5,964	5,741	54,593	53,705	116,512	111,791	13,107	11,200
TOTAL .	188,851	192,013	1,146,807	1,143,135	6,684,097	6,658,511	150,884	145,498

† Horses used for agricultural purposes, mares for breeding, and unbroken horses (including stallions). "Other horses" on agricultural holdings are not included; the total of these for Scotland is given in the summary table on p. 1.

ACREAGE of CROPS and NUMBER of LIVE STOCK in each COUNTY DISTRICT of SCOTLAND on 3rd June 1922.

County and District of County.		Wheat.	Barley (including Bere).	Oats.	Beans.*	Potatoes.	Turnips and Swedes.	Rye-grass and other Rotation Grasses & Clover. For Hay.	Rye-grass and other Rotation Grasses & Clover. Not for Hay.	Permanent Grass. For Hay.	Permanent Grass. Not for Hay.	Horses.†	Cattle.	Sheep.	Pigs.
		Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	No.	No.	No.	No.
ABERDEEN	Aberdeen	4	6,057	17,453	..	1,959	9,670	8,055	25,597	14	2,193	3,475	18,249	8.878	3,419
	Alford	..	887	16,934	..	347	7,809	5,284	22,002	83	4,904	2,685	15,516	38,743	677
	Deer	..	1,959	44,197	14	2,154	16,622	12,690	46,441	280	8,335	6,420	37,387	29,784	3,485
	Deeside	..	2,077	14,770	..	511	7,071	6,033	19,171	26	4,292	2,546	14,015	44,800	787
	Ellon	48	3,270	28,534	1	1,055	12,444	8,110	34,992	99	2,947	3,586	28,480	23,071	1,833
	Garioch	2	3,470	24,012	..	781	10,745	6,316	30,922	91	3,160	3,888	21,037	13,230	1,794
	Huntly	..	965	15,984	1	383	6,402	2,727	22,396	25	4,300	2,678	12,940	32,985	1,111
	Turriff	..	2,729	28,757	1	859	10,985	5,244	33,464	106	1,399	4,246	22,692	12,043	2,295
ARGYLL	Ardnamurchan	..	..	456	..	261	49	534	177	1,189	1,775	165	3,119	63,326	86
	Cowal	..	..	1,358	..	271	449	1,070	873	1,644	6,104	429	4,480	134,373	197
	Islay	..	10	4,158	..	595	1,240	2,988	2,451	1,615	18,456	1,317	10,403	76,484	621
	Kintyre	2	508	4,839	22	431	2,184	1,639	9,475	1,131	11,520	1,670	14,012	125,117	2,182
	Lorn	..	2	2,887		725	639	2,672	842	3,956	5,457	919	9,209	171,248	474
	Mid-Argyll	..	..	1,740	..	378	504	1,817	991	2,480	8,318	613	7,428	113,156	344
	Mull	..	632	2,267	..	604	307	1,685	529	2,184	6,306	1,086	7,761	72,138	370
AYR	Ayr	118	11	11,235	160	1,937	1,806	7,736	14,543	6,105	39,780	2,391	29,887	103,733	3,937
	Carrick	99	324	10,556	83	4,072	2,889	5,126	12,925	8,891	33,599	2,465	23,152	178,810	2,839
	Kilmarnock	386	2	10,810	24	1,155	1,332	8,638	12,904	5,420	39,527	2,617	32,028	27,878	4,284
	Northern	380	7	10,328	21	2,731	1,341	7,204	11,219	5,349	34,948	2,597	26,722	38,573	1,328
BANFF	Banff	3	6,520	26,977	27	1,297	11,906	6,041	32,891	178	2,533	4,982	26,091	16,528	2,591
	Keith	..	1,344	21,938	2	551	8,200	4,766	24,463	105	7,264	3,794	17,574	45,487	1,143
BERWICK	East	1,317	6,044	9,216	149	1,548	6,755	4,065	14,742	387	14,855	1,525	4,478	77,438	2,488
	Middle	1,519	7,874	10,527	108	908	8,243	5,473	13,146	615	19,181	1,759	6,281	109,053	1,616
	West	217	2,378	10,738	6	527	6,468	2,719	19,201	1,152	18,017	1,244	4,944	130,754	864
BUTE	Arran	1	5	2,463	19	667	451	1,266	2,356	294	4,343	680	4,627	30,660	338
	Bute and Cumbrae	6	2	2,593	..	499	884	1,348	3,704	109	4,199	653	5,012	7,937	333
CAITHNESS (Not divided)		..	650	31,330	..	1,360	11,515	10,130	25,621	993	25,357	5,631	20,127	147,513	2,390
CLACKMANNAN (Not divided)		432	176	3,175	219	449	781	1,525	1,845	944	5,598	802	3,422	12,783	645
DUMBARTON	Eastern	531	..	3,945	18	1,385	674	3,299	2,793	633	9,053	977	6,109	10,798	703
	Western	131	16	3,713	10	1,377	719	2,528	3,088	1,064	11,447	909	7,528	55,001	409
DUMFRIES	Annan	8	161	13,363	..	1,475	4,615	6,237	13,487	2,733	15,685	2,264	15,294	41,859	2,450
	Dumfries	61	23	9,835	..	1,330	3,414	4,142	11,934	2,068	14,528	1,066	13,367	50,179	2,116
	Langholm	..	4	2,395	..	212	990	1,533	2,808	3,088	7,466	541	5,361	119,478	577
	Lockerbie	27	104	9,364	..	747	3,742	5,100	12,490	5,421	25,122	1,818	17,995	148,300	1,530
	Thornhill	..	..	6,237	..	528	4,330	4,146	7,638	5,051	32,289	1,279	15,708	185,063	2,331

* To be harvested as corn.

† See Note on p. 5.

County and District of County.		Wheat	Barley (including Bere).	Oats.	* Beans.	Potatoes.	Turnips and Swedes.	Rye-grass and other Rotation Grasses & Clover. For Hay.	Rye-grass and other Rotation Grasses & Clover. Not for Hay.	Permanent Grass. For Hay.	Permanent Grass. Not for Hay.	† Horses	Cattle.	Sheep.	Pigs.
		Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	No.	No.	No.	No.
East Lothian	Eastern	1,746	5,574	5,487	34	3,414	4,816	3,539	6,135	264	8,666	1,228	2,830	63,284	849
	Western	4,526	8,463	12,229	27	4,814	7,844	6,487	10,255	453	12,252	2,133	5,749	60,273	2,276
Fife	Cupar	4,228	4,353	14,791	53	6,538	7,279	7,788	13,606	303	14,167	2,734	9,515	36,519	2,192
	Dunfermline	1,515	703	8,052	119	1,980	2,599	4,824	4,016	1,440	20,096	1,754	8,797	21,705	1,487
	Kirkcaldy	2,839	2,517	10,164	2	4,046	4,117	6,887	5,962	703	13,545	2,140	9,004	16,090	2,479
	St. Andrews	5,204	5,945	11,948	69	6,001	6,973	8,306	7,828	763	17,497	2,859	10,773	17,664	2,097
Forfar	Arbroath	2,804	4,884	10,253	..	4,500	6,167	5,025	10,186	159	2,649	1,813	7,010	5,998	1,060
	Brechin	2,758	6,181	17,725	18	4,588	9,374	7,553	19,057	319	6,471	2,573	11,982	61,948	1,705
	Dundee	2,981	2,907	10,313	..	5,059	5,591	4,950	9,489	228	3,550	1,760	8,152	13,978	2,160
	Forfar	2,576	4,724	17,789	..	5,417	8,699	6,897	20,441	518	10,504	2,770	13,060	84,003	1,991
Inverness	Inverness	..	2,059	7,380	..	461	4,292	3,149	10,823	192	4,059	1,585	6,393	39,103	759
	Aird	48	203	6,060	..	544	2,623	3,004	5,207	498	4,708	1,182	6,043	41,648	678
	Badenoch	..	98	4,345	..	191	1,700	2,334	4,116	1,077	8,811	816	4,754	91,023	202
	Lochaber	..	1	1,282	..	491	268	1,459	482	2,006	2,673	432	5,290	138,700	169
	Skye	..	11	5,641	..	1,311	308	1,469	427	2,235	4,883	1,108	10,470	124,601	4
	Harris, N. & S. Uist	..	2,705	6,318	..	2,300	106	290	90	1,293	30,674	3,060	14,197	61,126	17
Kincardine	Laurencekirk	517	1,984	9,442	..	1,883	4,226	3,707	8,521	72	2,146	1,166	5,035	14,809	573
	Lower Deeside	..	1,268	3,436	..	819	1,748	2,172	3,517	13	314	640	3,033	264	452
	St. Cyrus	798	2,006	5,862	15	1,241	2,952	2,715	5,170	69	2,310	858	3,172	7,207	354
	Stonehaven	167	2,742	8,009	16	900	4,187	3,792	9,383	61	2,011	1,357	7,540	11,393	751
	Upper Deeside	..	1,477	3,806	..	293	2,150	1,667	5,820	..	1,173	771	3,861	5,675	377
Kinross (Not divided)		219	154	7,264	3	1,449	2,324	3,776	7,379	721	10,093	1,274	5,520	29,079	725
Kirkcudbright	Eastern	6	14	10,552	1	1,021	4,042	4,728	15,751	3,012	24,022	2,072	19,208	63,226	8,443
	Northern	..	..	1,860	..	127	769	876	4,391	2,575	9,196	503	5,858	142,228	807
	Southern	12	23	10,276	1	349	4,492	4,142	28,839	4,649	25,543	2,219	25,016	75,009	7,055
	Western	..	2	2,212	..	92	862	1,140	2,611	1,490	10,644	499	5,039	82,898	520
Lanark	Lower Ward	1,058	66	4,219	7	1,409	598	3,443	1,888	1,959	6,713	900	4,708	458	2,130
	Middle Ward	1,358	61	17,653	9	2,461	3,253	18,088	13,475	5,315	50,494	4,090	37,241	27,456	2,827
	Upper Ward	43	7	18,603	..	2,367	7,778	12,617	21,700	4,057	44,902	3,344	30,166	198,020	2,048
Linlithgow	Bathgate	367	347	5,477	..	668	1,151	3,526	2,812	570	13,292	1,134	6,787	6,090	415
	Linlithgow	2,571	1,494	5,898	29	2,031	2,111	3,676	2,571	410	7,404	1,116	4,563	7,922	1,317
Midlothian	Calder	1,871	710	5,870		1,847	1,779	3,757	2,781	904	12,394	1,178	5,558	33,702	1,559
	Gala-Water	315	1,286	6,145	..	438	3,715	1,681	10,217	295	14,557	755	2,791	95,587	284
	Lasswade	1,042	1,620	6,104	..	2,159	2,760	3,581	2,522	628	8,268	1,119	3,757	33,911	1,151
	Suburban	2,804	1,037	3,699	3	2,804	1,377	2,820	319	180	3,391	801	3,928	7,432	8,483
Moray (Not divided)		785	9,696	24,692	20	1,717	13,652	5,908	33,970	265	6,857	4,911	21,267	44,754	2,232

* To be harvested as corn.

† See Note on p. 5.

ACREAGE of CROPS and NUMBER of LIVE STOCK in each COUNTY DISTRICT of SCOTLAND on 3rd June 1922.

County and District of County.	Wheat	Barley (including Bere).	Oats.	Beans.*	Potatoes.	Turnips and Swedes	Rye-grass and other Rotation Grasses & Clover. For Hay.	Rye-grass and other Rotation Grasses & Clover. Not for Hay.	Permanent Grass. For Hay.	Permanent Grass. Not for Hay.	Horses†	Cattle.	Sheep.	Pigs.
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres	Acres.	Acres.	Acres.	Acres.	No.	No.	No.	No.
NAIRN (Not divided)	18	2,230	6,224	1	278	3,765	1,966	9,166	30	1,781	1,370	6,079	13,744	877
ORKNEY — Mainland	..	1,053	19,205	..	1,237	7,047	5,675	15,635	405	7,236	3,656	16,321	13,365	926
ORKNEY — North Isles	..	2,154	10,235	..	753	4,730	2,500	10,376	39	5,486	2,111	10,737	15,015	747
ORKNEY — S. Ronaldshay & Walls	..	303	5,656	..	341	1,855	1,428	3,605	44	1,054	795	4,249	5,733	168
PEEBLES (Not divided)	8	310	6,923	..	417	3,124	2,587	11,5[illegible]	1,271	23,764	1,048	6,588	200,738	423
PERTH — Blairgowrie	2,246	1,554	16,386	..	5,545	6,188	7,233	15,786	387	11,490	2,489	11,561	54,292	1,695
PERTH — Central	807	105	16,193	.	3,009	4,890	7,590	13,548	1,352	16,995	2,669	11,980	119,771	1,951
PERTH — Highland	23	71	7,205	..	937	2,562	4,903	6,532	2,382	14,087	1,452	8,912	188,208	1,207
PERTH — Perth	4,867	1,717	22,821	253	7,357	8,651	11,195	18,711	1,612	21,069	3,686	16,933	51,911	2,783
PERTH — Western	370	226	10,807	447	2,117	2,248	5,761	7,077	4,778	16,508	2,443	12,420	168,659	930
RENFREW — First or Upper	1,247	4	4,797	5	1,455	1,066	4,882	2,463	3,894	21,507	1,345	12,523	17,195	1,595
RENFREW — Second or Lower	705	5	5,852	50	2,009	1,119	5,162	4,772	2,441	20,483	1,597	12,960	19,001	1,380
ROSS & CROMARTY — Black Isle	16	2,830	6,759	..	807	4,097	3,296	9,470	78	1,153	1,498	5,407	12,766	773
ROSS & CROMARTY — Easter Ross	661	1,938	9,904		1,467	5,443	4,282	12,828	465	5,729	1,990	8,225	64,369	1,555
ROSS & CROMARTY — Mid Ross	76	1,545	9,322		758	4,320	4,315	10,491	401	5,425	1,825	8,483	67,789	1,006
ROSS & CROMARTY — S.-W. and Western	.	17	1,966	..	673	223	1,563	400	1,347	2,152	389	4,810	68,976	82
ROSS & CROMARTY — Lewis	..	2,596	3,437	..	3,362	150	232	104	146	9,324	1,052	11,513	51,211	17
ROXBURGH — Hawick & Liddesdale	8	98	3,639	4	185	1,921	1,445	5,231	3,727	13,099	663	4,824	176,982	615
ROXBURGH — Jedburgh	110	1,873	8,108	7	286	4,985	2,825	17,956	1,520	16,572	1,164	5,684	150,832	767
ROXBURGH — Kelso	530	6,323	8,794	77	597	7,101	3,640	15,433	843	13,183	1,265	4,915	134,664	1,169
ROXBURGH — Melrose	119	1,287	6,385	..	207	3,673	2,123	9,545	847	13,126	775	3,207	63,774	688
SELKIRK (Not divided)	15	339	4,135	..	176	2,145	1,393	6,728	1,796	13,087	582	3,327	183,055	600
SHETLAND — Mainland	..	705	5,490	.	1,810	870	970	565	1,204	8,391	1,952	10,345	120,240	306
SHETLAND — North Isles	..	21	1,250		443	132	314	106	521	2,781	1,077	3,238	32,661	225
STIRLING — Central	988	510	7,773	843	1,442	1,649	4,286	4,005	4,056	16,943	2,049	11,593	39,191	984
STIRLING — Eastern	1,044	503	6,433	580	948	1,231	4,328	2,409	1,437	15,877	1,376	8,674	5,491	847
STIRLING — Western	162	11	4,963	18	1,165	1,052	3,462	3,138	1,628	17,974	1,224	10,168	60,603	559
SUTHERLAND (Not divided)	..	448	8,142	.	1,208	2,826	4,531	5,699	1,410	6,169	2,252	10,451	200,960	731
WIGTOWN — Machars	86	173	12,058	52	368	4,778	4,361	20,437	3,655	29,660	2,716	25,643	64,970	4,161
WIGTOWN — Rhins	5	40	18,687	14	1,348	7,949	2,087	31,882	1,244	14,468	3,248	28,950	51,542	8,946

* To be harvested as corn.

† See Note on p. 5.

BOARD OF AGRICULTURE FOR SCOTLAND.

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THE FUNCTION OF THE STATE IN ITS RELATION TO THE AGRICULTURAL INDUSTRY.

CAPTAIN WALTER ELLIOT, M.P.

THE condition of agriculture at the present moment is serious, not to say critical, and even the farmers, by training and long tradition the most individualistic members of the community, are asking where they stand and whether the new goddess of Plenty—the State—can by some miracle produce a quart out of a pint pot, or make sun to shine on them. Depression in agriculture is serious not merely to one class but to all classes in the community, since in the number of persons employed, in its money turn-over, and in its relation to the health of the people, it stands pre-eminent among the industries even of Britain. In the coming months it will be more necessary than ever before to keep a firm hold on realities and not to permit ourselves to be carried away by the flood of sentimentalism which is about to be poured over this great industry. Agriculture is about to become a stunt, a news-feature, a pawn in the game of the political chess board—and at such periods a cool head, a stout heart and above all a knowledge that two and two cannot be induced to make five, will prove themselves as necessary as they will assuredly be unpopular.

All over the world the slump has come; but for our purpose it is essential to note that it has struck first of all, and heaviest of all the primary producers, the men who hew coal, the men who make meat, the men who grow corn—these, competing as they do in the world market, have had to bear the burden of the world drop. The problem is reinforced and accentuated by the fact that the great distributive trades, working as they do on an internal monopoly have been able to pass on a great part of their suffering. In 1922 at Methil Docks the man who watched coal pouring down the chute into the hold of a ship was earning a minimum of £9 and a maximum of £12 per week. The miner who won the coal—of whom four are killed per day, Saturday and Sunday, year's end to

year's end—was getting some 45s. a week and enduring broken time at that. In agriculture by last December 28s. per week was not an unusual rate in England. This works out at about 15s. 6d. pre-war.

The people of these islands, 78 per cent of whom live in large towns, have no mind to endure one farthing's extra cost on any article of such prime necessity as food. We must therefore take into account the state of agriculture in the countries oversea, from which come four loaves out of every five that we eat, and half at least of every pound of meat. We shall find that the plight of British agriculture is not unique. Last year, for instance, the complaints against underselling of our potato growers by the Dutch importers were widespread and bitter. A study of the Dutch newspapers showed that the same complaints against impossible prices, were broadspread in Holland—the Dutch farmer, caught with a full stock in a falling market, was squeezed into unloading at any cost. In the United States the American farmer reckoned that he was selling at under the cost of production; in South America many of the great freezing stores had closed down because it no longer paid to chill the meat and carry it to Europe, while up and down the great estancias, and even by the roadside, could be seen carcases rotting in the open after the hide had been removed, because the meat would not pay the cost of transport to the packing house.

The insular position of Britain brings home these economics—these heights and hollows of the world-market—to every housewife in the land. Nearly 60 per cent. of our people live within twenty miles of tide-water; that is to say they are nearer to an ocean going ship than to any but the most adjacent farms. It is foolish to complain against the cost of home transport as some of us do. The North Sea, for instance, is little more than a big pond, and the great London market, facing dead across to Holland, receives, and is bound to receive, Continental products across the few intervening miles of water at a rate against which only the most keenly-cut transport enterprises in this country will ever be able to compete.

In such circumstances the cranks and the theorists are not slow to mass their brigades and advance to the attack. The eye is dazzled by the constant whirl of figures dancing in the hands of some competent statistic juggler, the ear is deafened by confident assertions as to what the land of Britain could or should produce, volunteered by gentlemen without one single practical point of contact with the soil, united only in their opinion that the present cultivators of the land are the worst and most ignorant of all possible cultivators, and that the methods they employ are the most wasteful and foolish that ignorance and folly could devise or adhere to.

Some of the theorists referred to above even believe that remedies for our trouble may be found in attacks upon the "landlord," who is supposed to be exploiting in some unscrupulous

fashion "the land, the land, the land on which we stand," as sung recently in the House of Commons by a number of members standing on the second storey of a very expensive building. A short reference to arithmetic may help to keep us straight. In 1913 the landowners derived the gross rental of forty-two millions a year from England and Wales; nineteen millions were immediately taken by the State in income and super-tax. Seven millions were required for repairs and renewals and three millions for expenses. This left an average of 8s. per acre. I leave it to the reader to determine whether the taxation situation has become better or worse since the year before the war. In fact, the attack has already been pushed dangerously far. The function of the "estate" in the economics of agriculture was to serve as a flywheel in which energy was stored during the fat years to carry the industry over the dead centre of the inevitable depression. What is more, the home farm on progressive estates, provided an experimental station to which we owe many of the advances in practical agriculture. Any section of the community which believes that there is still a henroost here to be robbed, is suffering the most tragic of delusions; the only egg that is left is the china egg, as would be discovered within a very short time of making the experiment.

What is Wanted.—Let us therefore keep clearly before us the nature of the problem and examine the suggested remedies.

The nation wants :—

(1) An increased and cheapened production of food stuffs.

(2) An increased number of people on the land.

The investor and the agriculturist want an industry which can yield a reasonable return for the work put into it. Unless the industry can show this reasonable return from its own resources, it is impossible to suppose that any increased population can be induced to go on the land, or indeed that we can maintain those already there. If the industry shows a profit, capital and labour alike will flow into it, and more people will be employed. Witness the boom in hen farms and piggeries in 1920. Unless there is a profit, any artificial scheme to put people on the land, such as dumping down ex-soldiers to starve on small holdings, is bound to collapse. It is often forgotten, when the usual figures are quoted about the greater production per acre, for instance, in Germany or Denmark, against that of this country, that there is another side to the question. If we take as the basis of our calculation, not the number of persons fed by each acre of land, but the number of persons fed by each worker on the land, we get a very different story. In Britain a man working on the land feeds over eight people for a year, in Germany the corresponding figure is only four. Again in Denmark their production is achieved to some extent by the sacrifice of school children, whose school year is hundreds of hours shorter than that in Britain. What is more, the Danish farmer produces butter—but eats margarine. The costly product is shipped overseas to be eaten by the industrial population of Great

Britain. What do these figures indicate? They indicate that the law of diminishing returns is already valid as between ourselves and some of the Continental countries. It is useless to seek for an avenue of escape from our present agricultural depression by sending to the help of a worker who is feeding eight men a worker who will be able to feed only four, so that the two together can only feed six apiece—and be paid accordingly.

The problem of small holdings is the problem of some additional occupation. It is not possible so to organise a small holding in a rain-soaked island that it will give a man as many full days remunerative work as can be obtained by the large-scale co-operative system which good farm management can produce. This means, if there is any meaning in arithmetic, that a small holder in many areas will have to accept a lower standard of living than his fellows, either of the town or of the country. He may desire to accept this, as do many men in the West Highlands, because of the freedom and leisure which this renunciation allows. But let us see that the position is clear to the minds of those about to take up such an occupation.

Let us consider the remedies usually suggested.

The first is the universal panacea of recent years, a State subsidy in one form or another, in which I include food tariffs.

The second is co-operation, with the elimination of the middle man.

The third is the only remedy which I consider practicable in the present circumstances—Science and Education.

State Subsidy.—The first remedy seems to be impossible. There is no money. What is more, if money were available it is wasted on working an expensive Government Department, on assessing subsidies, on paying subsidies, on inspecting, to see that the thousand and one technicalities of the paper forms involved have not been transgressed. And in addition it is an artificial stimulus. Let us not beg the facts; if agriculture cannot stand on its own legs it will have to shut down. It is worth while rescuing a drowning man and making him breathe for a while by artificial respiration. But if he is never going to breathe by himself, it means that the whole of a hale man's time is going to be absorbed, and instead of one dead man you are eventually going to have two. We have had one experiment with subsidies. It collapsed utterly as soon as ever the strain came, and would do so again. Similarly, less than a hundred years ago, we saw the throwing down of Protectionist barriers by the hungry multitudes of the great towns. This too would happen again if for a moment such obstacles could be erected.

Co-operation and Elimination of the Middle-Man.—There is no doubt a number of parasites in the industry of agriculture. For all that, there is a great deal of nonsense talked upon this subject. Collection and distribution have got to be paid for. If the field of distribution were a treasure ground whereon pockets

full of money could be picked up by any comer, the number of exploiters would be doubled in a week. It is considered by some people, and the Socialists have done much to spread this error, that the distributor produces nothing. and merely sells the product of another's labour for his own benefit. They are wrong. The distributor produces the commodity of all commodities the most valuable; he produces time, the time that he saves to the seller, the time that he saves to the buyer and, for this, only the experience of these two individuals can assess how much they think he should be paid. Sir Charles Fielding, K.B.E., in his recent book entitled *Food*, states that on bread, meat and milk, the middlemen of this country make a profit of £175,000,000 a year. It is no doubt a figure which could and should be reduced, but whether it will be better reduced by committees of farmers hiring officials on fixed salaries, or by individuals competing against each other for a living is a matter for no foregone conclusion. Co-operation is, however, worth trying But it must grow from the bottom and not be forced on us from the top.

Research and Education.—Let us be clear what we mean by scientific research. There is a popular idea that it is limited to work done in a laboratory with test tubes and microscopes. But science is a Latin word for knowledge. There is no essential difference between the science of the laboratory worker and that of, say, the stockman. Both are making observations, bringing them to a greater or less degree of exactitude, and carrying forward the results to guide them in experiments of the future. Agriculture is the practical application of all the sciences to the production of the necessities of life. Thus, in investigating the principles of feeding—of nutrition—the biochemist studying the interplay of atoms or of molecules in protoplasm, the physiologist studying the exchange of matter and energy in the body, the experimenter carrying through feeding experiments, are merely working at different aspects of the same problem. What is not so generally recognised is that the feeder, carrying through the fattening say of the 400,000 store cattle annually imported from Ireland—working with weighed quantities of food-stuffs, to produce a weighed quantity of meat, and the farm servant watching from day to day—even from hour to hour—with the clinician's eye the minutest variation in the health of these animals, are also scientists studying the same problems from two further, yet very closely related angles.

The laboratory man, working with his eye to the microscope too frequently in the past has neglected the wider survey whose necessity, in the abstract, he would be the first to recognise. Again, the practical man has tended to neglect the available scientific knowledge which solves many of the practical problems with which he finds himself faced. What is needed is a linking up of the first-class expert in pure science with the first-class expert in applied science, *i.e.*, the laboratory man with the first-class landworker. The recent centenary of Pasteur should remind us of what valuable results may thus be obtained, and the

laboratory scientist should never forget that Pasteur, master of them all, thought no time wasted that he spent in first-hand questioning of shepherds or stockmen, men who led their lives in day-to-day study of living creatures.

Under the Development Commission a scheme of research is now being promulgated to promote a more effective inter-change. Stations are being established where practical problems are attacked by pure scientists, working on lines suggested by practical experts. The Board of Agriculture for Scotland has adopted the most enlightened attitude in promoting and encouraging such research, as witness the excellent address delivered by Sir Robert Greig at the Rowett Institute on 18th January last.

It must not for a moment be supposed that either research or education will prove any substitute for hard work. All that they can do is to show at what point energy may most effectively be applied. The greatest knowledge in the world of the principles of mechanics will not suffice to heave out of the way some great boulder, unless the worker's full weight is thrown straining on the lever which his knowledge has permitted him to apply; but with the combination of knowledge and effort, it may well be that with a single thrust he can clear out of his way an obstacle which it would have taken him weeks of toil to hew laboriously in fragments and remove piecemeal. Examples of the proved value of scientific research crowd upon one too numerous to mention. In a recent article in the *Aberdeen University Review* (March 1920) Dr Orr has given a few striking facts. In 1875 for instance 11½ tons of beet were required to make one ton of sugar. In 1910 the quality of the plant had been so improved that only 6 tons were necessary. Again in 1919 Great Britain spent on imported food stuffs nearly sixty million pounds sterling. On this subject Mr K. J. Mackenzie points out "more feeding stuff than is necessary is used wholesale for the production of winter beef." We pay foreign countries for material which through ignorance is partially lost without any return. Sir Thomas Middleton has shown that for every hundred acres of cultivated land Germany produces 4·27 tons of meat against Britain's 3·97. This production is apparently not only greater but more economical, for the British farmer purchases annually 11·5 tons of concentrated feeding stuffs per hundred acres, while the Germans purchase only 8·7 tons.

The figures of direct loss from disease show again how great a wastage may here be prevented. In the twenty years prior to the passing of the Diseases of Animals Act, 800,000 animals were condemned and killed owing to pleuro-pneumonia and foot-and-mouth disease alone. In the twenty years after the passing of that Act only 4000 were so destroyed, though in the last few years larger outbreaks have again taken place. This figure gives some slight indication of the loss thereby averted. But in this field an immensity of effort still awaits us. In April 1920 Mr William W. Philip in the *Scottish Journal of Agriculture* estimates the deaths of sheep and lambs in Argyllshire alone from the common

sheep diseases as 92,000 per annum—valued at £150,000. "Were it not," he says, "that most of the hoggs in the county are removed annually for wintering, the death rate would be much in excess of that given, the death rate amongst hoggs wintered at home being about 20 per cent. The wintering of the hoggs sent away, is estimated to cost the flock-masters of the county £45,000 per annum." Losses from stock diseases are world-wide; but some have been successfully grappled with both within our country and abroad. In Montana (U.S.A.) for instance one million young pigs were lost annually from disease. Research in 1916 showed that this loss could be prevented by the addition of iodine to the ration of the sows. And for the question of the utilisation of feeding stuffs it will not be forgotten that work done at Aberdeen in the last two years has enabled us to find a market in Britain for 50,000 tons a year of fish-meal previously shipped to Germany, but now realised as one of the most valuable ingredients in our feeding rations here at home.

Problems of the Future.—The great Institute of Rothamsted has done much for arable farming in this country. A similar great work lies on our hands to do for stock farming. In this industry the rapid turnover of capital which can be achieved, *e.g.*, in pigs, make it possible both to employ more people and to make possible an intensive cultivation of feeding crops. Remember that here an almost unlimited market lies actually at our door, a market which in 1912 absorbed £280,000,000 worth of imported animal products. And there are avenues of advance as yet scarcely entered upon. In our tropical possessions, notably in those of the well-watered region of West Africa, we have the maximum possibility of the rapid conversion of the sun's energy into vegetable products. We can grow food-stuffs there and transform them here into meat, milk and eggs.

The same factors that have half-ruined British agriculture—the central position of this island, with cheap water transport from the ends of the world—may be made, if skilfully utilised, to yield its salvation.

But these are problems of the future. We do not need to look for questions. They lie before us on every mountain and in every valley. What we do require is to begin, here and now, looking for answers.

PASTEUR AND THE FARM.

PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

THE scientific world is or has been celebrating the centenary of Louis Pasteur, who was born on December 27th 1822, in the Tanners' street in the little town of Dôle, in the Jura. We rank him as one of the greatest men of science, not only because of his contributions to the theory of fermentation and disease, and not only because he greatly increased the wealth of his country and

saved so many lives, but especially because he was a logical link in the chain of those whom we venture to call life-controllers. He may be called, we think, the leader of those who have realised that it is chiefly through science that man can enter into his kingdom.

Personal.—It is impossible to explain how men like Pasteur arise, but it is often plain enough that they are not grapes that grow on thorns. Pasteur was a tanner's son, but his father had been a soldier, decorated on the battlefield, a bookish and thoughtful man. His mother was of enthusiastic temperament and shrewd intelligence. Louis seems to have been an ordinary enough schoolboy, not objecting to truancy, but always showing grit. After a a short time at the college at Besançon, where his interest in chemistry was awakened and his extraordinary working power first showed itself, he went to the Sorbonne in Paris, and had the advantage of good professors. Soon becoming known as a man of promise, he was called to Strasbourg as Assistant Professor of Chemistry, and there he married the rector's daughter. At the age of thirty-two he was appointed Dean of the Faculty of Science at Lille, where his interest in fermentation was rivetted. After three years he went back to Paris (1857) to the Ecole Normale, and eventually he became a Professor at the Sorbonne. All the rest was work.

Early Scientific Achievements.—The scientific investigator deserves a well-equipped and pleasant laboratory, and Pasteur eventually got his Institute. But no one can pretend that it is the laboratory equipment that is essential, and Pasteur did great things in a garret, some ten feet square. It is the cerebral equipment that counts for most.

Pasteur's early work was to all appearance very theoretical, and the list of his achievements, recorded around his tomb, begins with "Molecular Dissymmetry, 1848." He was interested in the two crystalline forms assumed by tartrates, right-handed and left-handed, and it was from a study of these that he was led to tackle the problem of fermentation. The story is that some manufacturer, who was puzzled by the fermentation of his commercial tartrate of lime, brought the matter under Pasteur's notice, and the result was the discovery of the fermenting micro-organism. It must be borne in mind, of course, that Cagniard Latour and Theodor Schwann had previously demonstrated the yeast-plant which ferments sugar into alcohol. On the other hand, it must also be noted that the prevalent theory of fermentation in Pasteur's early days was the chemical one, associated with the name of Liebig, that nitrogenous substances in a state of decomposition are able to upset the molecular equilibrum of fermentable matter with which they come in contact. What Pasteur did was to show that lactic, butyric, acetic and some other fermentations are due to the vital activity of specific micro-organisms. We now know that there are likewise non-living enzymes, such as diastase and pepsin, which also bring about fermentation. As we have said, Pasteur's interest in the

problem was rivetted by his period of work in Lille, where one of the chief industries was making alcohol from beetroot and grain.

Pasteur's researches on fermentation led to various practical results, such as the Orleans process of making vinegar, the improvement of wine and beer, and the curing of certain wine-diseases which mean more for France than for us. But they also led to a very important distinction between micro-organisms that require free oxygen (aërobic) and those that are able to live apart from free oxygen (anaërobic), obtaining what they need by splitting up oxygen-containing compounds in the surrounding medium.

It was not long after his return to Paris that Pasteur had his first encounter with the champions of spontaneous generation, who held that living creatures may arise in non-living matter, and with his punctilious carefulness he had little difficulty in scoring a victory—for the time being at least. For the heresy dies hard. Pasteur knew much more about the insidious ways of bacteria than did his antagonist Pouchet, and he was able to show how the living organisms that came out of the organic material had previously got in! In 1860 he gained a prize offered by the Academy for "well-contrived experiments to throw new light upon the question of spontaneous generation." We must not think of this recurrent problem as merely academic, for its consideration has led to improved methods of bacteriology and to new ways of preserving food-stuffs. The deeply theoretical is seldom very far away from the intensely practical.

Silkworm Disease.—In 1849 a strange disease broke out in the silkworm nurseries in the south of France. The silkworms would not feed; they died in their last moulting or earlier; sometimes the eggs would not hatch. The disease (pébrine) spread in France and into other countries; it got worse every year; the silk industry was threatened with entire collapse.

The story goes that when Pasteur was urged to come to the rescue of the silk-farmer, he objected on the ground that he had never even handled a silkworm. So much the better, Dumas replied, you will be free from prejudices! As is well known, Pasteur yielded, and saved the industry. Some Italian naturalists had described "peculiar microscopic corpuscles" in the eggs, silkworms, and moths, and Pasteur soon proved that they were the cause of the disease. His drastic remedy was one not now unfamiliar to the farmer of larger stock; it was to destroy all the infected silkworms, easily distinguished by their inability to climb quickly on twigs where the silken cocoons are spun; and then begin afresh with minutiose cleanliness. Whenever a caterpillar showed signs of weakness, it was to be eliminated; and thus a healthy stock was reached and sustained. It is often and rightly said that Pasteur saved France more than the indemnity paid to Germany; but what he did was truly incalculable, for he showed how a serious epidemic may be faced and baulked.

To the man himself the cost was great. When in the midst of his labours, spending much of his time in a hot greenhouse, where

the silkworms were kept, his physician had told him, "If you continue living in that place it may mean death; it certainly means paralysis." "Doctor," answered Pasteur, "I cannot give up my work; I am within sight of the end; I feel the approach of discovery. Come what may, I shall have done my duty." It was a fine gesture, but as the result of persistent overwork in trying surroundings, Pasteur had a paralytic seizure.

A catastrophic interruption of Pasteur's labours came with the Franco-Prussian war of 1870. "The strenuous spirit which well-nigh mortal illness had failed to bend was almost broken, and for a moment Pasteur lost heart for usual work amid the national grief. French patriotism, however, ever rises above despair, and work began afresh, stimulated now to a new intensity, more perfervid yet more tenacious than ever." "Il faut refaire la patrie," was the watchword for Pasteur and those of like temper, and it was with a fine resolution that each turned again to work. There followed such discoveries as the methods of dealing with splenic fever and hydrophobia—discoveries which brought world-wide renown and led to the opening of the Pasteur Institute in 1889. Its "Annals" show what a gift Pasteur had in inspiring other workers as well as doing things for himself. After a period of partial disablement, and another attack of paralysis, Pasteur died on the 28th September 1895, in a grand old house at Garches, which had been placed at his disposal for special researches. Thus he died as he lived, in his laboratory; and if, as one of his countrymen puts it, there is one word more than another which his life suggests, it is the word *Labeur*.

Anthrax or Splenic Fever.—As a typical example of Pasteur's work we may consider his discoveries in connection with anthrax or splenic fever, a very serious disease of herbivorous animals, notably cattle and sheep. In severe cases the animal collapses, as if it had received a heavy blow, and falls into convulsions. The disease occasionally attacks man, especially when there has been handling of imported wool and hides.

About 1854, the French pathologist Davaine found that the blood of sheep suffering from anthrax contained countless swarms of a rod-like bacterial parasite, and experiments led to the conclusion that it was the cause of the disease. It was not till 1878, however, that Koch, who was at that time an obscure country physician, tackled the life-history of the bacillus and cleared it up definitely. Where then did Pasteur come in? He confirmed Koch's work with independent observations, and then went far beyond it. There is great interest in the steps of his investigation. It was known that birds did not "take" anthrax, and Pasteur attributed this to their high temperature, *e.g.*, 42° C., which approaches the limiting temperature for the multiplication of the anthrax bacillus. So Pasteur chilled a fowl to 37° or 38° C., and inoculated it. The result was that it died in twenty-four hours. Again he inoculated a chilled fowl, let the splenic fever develop, placed the bird wrapped in cotton wool at a suitable temperature, and saved it!

Another step was the cultivation of an attenuated or "tamed" stock of the microbe which he used in the inoculation of fowls with the result that they were safe when afterwards infected with the virulent or "untamed" form of the bacillus. This was different, obviously, from Jenner's vaccination, which consisted in protecting man from the virulence of small-pox by previous infection with the milder microbe of cow-pox.

The next step was the cultivation of the bacillus exposed to air at a temperature of 42° to 45° C., at which no spores are formed. The result was an attenuated virus with which he proceeded to inoculate sheep and cattle. This is the story of "the victory of Melun." The Agricultural Society there had placed at Pasteur's disposal sixty sheep and ten cows. Ten sheep were to receive no treatment at all; twenty-five were to be inoculated with the attenuated virus; and these, along with the other twenty-five, were eventually to be infected with the virulent form of the anthrax bacillus. Similar things were done with the cows. On June 2, 1881, over two hundred experts and others met at Melun to witness the result of the experiment. Out of the twenty-five sheep that had not been inoculated, twenty-one were dead and two were dying. The cows that had not been inoculated were fevered and off their food; those that had been inoculated had shown no rise of temperature, and were eating quietly. The "shout of admiration" that went up from the crowd was heard all over the world.

We are not asserting that Pasteur's work on splenic fever was the last word on the subject, for that is not the case; but it is certain that he made a great stride towards the conquest of the disease, and that he started a method of preventive inoculation which has been prosecuted in other cases with remarkable success. Professor W. T. Councilman writes:—"Looking at the matter from the lowest point of view, the money which has been saved by the control of the disease, as shown in its decline, has been many times the cost of all the work of the investigation which made the control possible. It is a greater satisfaction to know that many human lives have been saved, and that small farmers and shepherds have been the chief sharers in the economic benefits. The indirect benefits, however, which have resulted from the application of the knowledge of the disease, and the methods of investigation developed here, to the study of the infections more peculiar to man are very much greater."

Pasteur and the Fields.—But we miss much of the instructiveness of Pasteur's work if we stop the story of anthrax at this point. Pasteur, like Jenner, was a scientific rustic, and he knew his fields and what happened there. The sheep and cattle are infected with anthrax by eating grass and the like on which there lie the virulent microbes or their very resistant spores. The contamination occurs when the dead animal is skinned on the field, or when infected stable manure is spread on the ground; and the microbes may be carried by rain and wind from field to

field. But Pasteur, with his "instinct" for punctilious cleanliness and his realisation of the subtle pervasiveness of bacteria, saw more deeply. He showed by careful experiments that when animals which had died of anthrax were buried in certain soils the microbes live on. The earthworms bring them to the surface in their castings, and they are scattered hither and thither. "Therefore," said Pasteur, "we should never bury animals in fields destined either for cultivation, forage, or sheep pasture." When it is possible, a sandy soil should be chosen for the purpose, or any poor calcareous soil, dry and easily desiccated—in a word, soil not suited for earthworms. Best of all, perhaps, the dead animals can be burned in a destructor. But the interesting point, as it seems to us, is Pasteur's appreciation of the subtlety of nature. He meets with Darwin, as it were, in the study of earthworms and the part they play in the intricate web of life. Pasteur was one of the pioneers in the study of "the living earth" and the part that its tenants, both large and small, play in its economy. Along the line of the biology of the soil there remains a great deal to do.

Hydrophobia.—We hold as a clue to the interpretation of Pasteur, that he was the scientific rustic. He was not a genius, but he had extraordinary grip and grit, as his face showed, and he had hold of a key, labelled bacteriology, with which he opened door after door. But it was with rural problems that he was most concerned. A tanner's son, he was therefore naturally a bacteriologist, for at more than one stage in the tanning there is an important, still imperfectly understood, activity of bacteria. A son of the country, he carried his microscope to the dungheap, to the manure-covered fields, to the vat and the wine-press, to the byre and the sheepfold, to the silkworm farm, to the dead sheep and cattle, and to the soil which the earthworms put into circulation. It seems natural, then, that he should also have turned his attention to that tragedy of the country side, more frequent in bygone days, when the mad dog runs amok.

What Pasteur did in connection with hydrophobia or rabies was fourfold. He showed that the disease, produced by the saliva introduced into the patient by the bite of the "mad dog," is particularly associated with the nervous system. He also discovered methods of attenuating the virulence of the virus. Thirdly, he showed that inoculation with the attenuated virus renders an animal immune to infection from rabies: by a graduated series of inoculations, the animal treated may be rendered so refractory that if it is bitten by a "mad dog" it will not die. But, fourthly, Pasteur showed, that even if the organism—man, let us say—has been bitten, it is still possible to ward off the terrible disease, unless the bites are near the head—that is, within close reach of the central nervous system. For in the case of a superficial wound, very probably on the leg or hand, the virus takes some considerable time to spread, and during this period it may be possible to baulk the virulent virus by inoculation with the attenuated form.

Perhaps the problem is not so clear as in the case of anthrax, for Pasteur did not discover the rabic microbe, if there is one. It is also probable that there have been failures and mistakes. But we are sure personally that if we were bitten by a "mad dog" we should make for the nearest Pasteur Institute. It is extremely unlikely that there was not a sound basis for the report which was presented to Parliament in 1887, in which Sir James Paget, Sir Lauder Brunton, Professor George Fleming, Sir Joseph Lister, Dr Richard Quain, Sir Henry Roscoe and Professor Burdon Sanderson declared:—"It may, hence, be deemed certain that M. Pasteur has discovered a method of protection from rabies comparable to that which vaccination affords against infection from small-pox."

Pasteur's Legacy.—We have seen that Pasteur made great contributions to the theory and practice of fermentation, to the germ-theory of disease, to preventive measures by means of inoculation, to the hygiene of man and beast and to the manifold *rôle* of bacteria in the bundle of life. Important in himself, he was not less important as a link in a chain—making other great life-savers possible. On every radius on which he worked—the rustic as thinker—he left a method or a clue, a disciple or a school. He was certainly one of the great Initiators, and it is on the farm, as much as in the hospital, that we should pay him homage.

AGRICULTURAL EDUCATION AND RESEARCH IN SCOTLAND.

Alex. M'Callum, M.A., LL.B.

PART II.

The West of Scotland Agricultural College.

In respect of agricultural education the deliberate policy of the second Board of Agriculture from its institution in 1889 was to encourage the development of teaching centres which would serve wide areas, and round which the educational machinery of the district would be organised so that in each district there would grow up a graduated and complete organisation of agricultural instruction. Thus provision would have to be made for three types of student—(*a*) young persons who would later be absorbed into the industry of agriculture; (*b*) those already engaged in agriculture; and (*c*) those who intended to become teachers. The first class would be dealt with in continuation classes, in secondary schools, and in collegiate courses according to their ability and their financial circumstances. The second class would have to be provided for by regular courses of lectures held at numerous local centres, and also by the formation of field demonstration stations where points of agricultural science could be

illustrated. The third class consisted of two groups: (1) those who were to be teachers in elementary schools, and (2) those who were to be county instructors or college lecturers on agricultural subjects. For the first group the main essential is a general knowledge of agriculture combined with a study of one or more of the sciences bearing on agriculture, *e.g.*, chemistry, botany, physics. The aim should be to equip the teacher with such a knowledge of the practice of agriculture as will enable him to see clearly the bearing of the sciences on it, and on the other hand to enable him to interpret to the farmer such scientific facts or theories as may from time to time confront him. In the case of the intending college lecturer the duties he will be called on to carry out demand a full and thorough training in agricultural science at a University or College.

Such was the organisation planned by the Board of Agriculture for each of the unit areas in the country, and in the case of Scotland, the Board were in a way responsible for the formal recognition of three areas, with centres at Aberdeen, Edinburgh and Glasgow respectively. This division had, however, in a measure come about spontaneously, and reflected a natural division which marked the north-eastern province as predominantly a stock-rearing area, the south-eastern as a crop producing area, and the south-western as a dairying area.

Briefly, then, the intention was to develop at each of the centres named an institution equipped to provide full courses of instruction in agricultural science, and staffed to carry into the different counties of the province agricultural instruction of a more elementary kind.

This yoking together of the agencies for the central higher training and the more elementary instruction of the practical agriculturist was tentatively tried in the north-east, where in 1880 and subsequent years itinerant lectures were given in Aberdeenshire by the University Fordyce Lecturer, Mr Jamieson. But the scheme first took definite shape and substance in the south-west province, where, as we have seen, there existed from 1886 onwards a central course in agriculture taught by Mr (afterwards Sir Robert) Wright in Glasgow, and likewise a series of fixed and itinerant dairying courses in the south-western counties. In a memorandum submitted by Mr Wright in 1891 to the governors of the West of Scotland Technical College—in which institution he was then carrying on his agricultural course—Mr Wright outlined a plan of operations whereby the two sets of agricultural activities were to be combined. At the college a department of agriculture was to be constituted and the teaching developed. In the province—defined as the ten counties of Argyll, Bute, Dumbarton, Stirling, Renfrew, Lanark, Ayr, Wigtown, Kirkcudbright and Dumfries—agricultural and dairy instruction was to be extended and developed under the guidance of county committees, while the county committees would have their proposals co-ordinated by a central committee. The actual work of instruction was

to be carried out by teachers and lecturers on the staff of the agricultural department of the Technical College. Proposals were made for the delivery, at populous centres, of courses of lectures in agriculture for the Science and Art Department examinations, and at smaller towns and villages of shorter courses and individual lectures on special subjects of local interest; for the arrangement and supervision of field experiments; for the oversight of any elementary school teaching of agriculture that might be given; and for the training of elementary school teachers in agricultural science. On the dairying side the practical cheese and butter-making classes were to be continued, but were to be supplemented by courses of theory at Kilmarnock and elsewhere.

This scheme was approved by the Governors of the Technical College, and in April 1891 Mr Wright was appointed Professor of Agriculture. In this capacity he gradually built up a department of agriculture in the college, with lecturers on chemistry, botany, dairying and general agriculture.

For some years this agricultural department of the Technical College continued to carry on important educational work mainly in the south-western area. Besides the regular courses of lectures in the college itself, courses were given at the Dairy School, Kilmarnock, and at numerous centres in the counties. During these years the local taxation money became available for purposes of technical education, and arrangements were made by the Department to supply the services of members of staff to such counties as were prepared to make a contribution from that grant towards the college expenditure. In this way lectures to farmers and systematic courses for younger people were given, not only in the south-western counties but also in other districts, such as Caithness, Argyll, Fife and East Lothian.

A special feature of the Department's work was the institution in different counties of field experimental plots, at which demonstrations were arranged for farmers in the locality. This proved a most successful method of arousing interest in the educational efforts of the staff. In that respect the work of Professor Wright deserves special notice, as he was the pioneer in Britain of this combination of demonstration and teaching. The farming community was slow to recognise the benefits to be derived from theoretical instruction, but when they had ocular demonstration provided for them in these experimental plots of the success of the scientific application of manures or the excellences of newer varieties of cereals, they became gradually more sympathetic towards the scientific aspect of the industry. Newspaper reports and leaflets with results of field trials were useful agents in spreading this interest, and conveying useful information to the farmer.

The establishment of a permanent dairy school at Kilmarnock has already been noted. The school, known as the Scottish Dairy Institute, was maintained by grants from several County Councils in the area, from local agricultural societies, from the Highland

and Agricultural Society and from Government sources, and by subscriptions from individuals. Its affairs were controlled by a committee of management, on which Mr Andrew Clement, Mr Alex. Cross, and Mr W. H. Ralston were prominent, and of which Mr J. Harling Turner, one of the original promoters, acted as honorary secretary from first to last. A lease of the cheese-making premises at Holmes Farm, Kilmarnock, was obtained, and these were equipped to suit the purposes of the school. To begin with, the training was entirely in practical cheese-making, but, subsequent to the arrangement made in 1891 for co-operation with the agricultural department of the Glasgow Technical College, a certain amount of theoretical teaching was given by members of the staff of the College.

These arrangements for agricultural and dairying instruction at the two centres and in the counties continued for several years, and were attended with a good deal of direct success. Their indirect effect, however, is to us even more interesting. It is difficult to determine now from what locality the suggestion came first, but the idea of a fully organised Agricultural College appears to have got into the air at that time, and to have been discussed and variously dealt with in different parts of the country. Thus the School Board of the City of Perth in the spring of 1896 made a formal proposal to the Secretary for Scotland—Lord Balfour of Burleigh—for the establishment of a college at Perth. They claimed to have carried on successfully in Perth Academy agricultural science courses for the previous five years, these courses being attended by from thirty-three to ninety students, and comprising classes in agriculture, agricultural chemistry, geology, botany, physiography, manual instruction and drawing, taught by a staff of highly-qualified specialists. The memorialists emphasised the central position of Perth, and its importance as an agricultural emporium. Again, in 1897, the County Council of the Stewartry of Kirkcudbrightshire gave formal expression to the opinion that some more permanent organisation than any then existing was required to develop agricultural education in Scotland. They called a conference of representatives of the County Councils of Ayr, Renfrew, Wigtown, Kirkcudbright and Dumfries, and this conference agreed that an attempt should be made to establish a central institution where agricultural education of an advanced type should be available to resident students, which should serve also as a source of advice and information on all matters affecting the agricultural industry, and from which lecturers could be supplied to conduct local classes where required. The institution was to be situated on a farm upon which the resident students were to take part in the work and obtain practical experience in crop growing and in stock-husbandry. The conference was bold enough to think that "County Councils might see difficulties in the way of supporting a small and meagre scheme, which would not present themselves were the institution based upon broad and comprehensive lines, assuring the existence of a permanent and

thoroughly efficient establishment under their control." An old mansion-house was suggested as the headquarters of the institution, and an annual charge of £2000 was estimated to be met from public funds and other sources.

So, too, at the annual conference of the Scottish Chamber of Agriculture, held in Edinburgh in October 1897, a motion was unanimously adopted to the effect that the grants for technical education should be made permanent, and that a portion of them should be devoted to the establishment of a school or schools of agriculture, where theory and practice could be taught and experiments conducted. The Chamber even went so far as to draft a scheme for an Agricultural College for Scotland. The draft scheme is interesting, but in view of later developments it is remarkable mainly on account of its vagueness in matters of detail and its optimism in respect of finance. A total annual expenditure of £2000 as proposed would have been hopelessly inadequate to carry out the functions which the college was intended to perform.

Not only representatives of local administrative bodies and of agricultural associations were occupying themselves with the development of agricultural education. Ever since the transference of the administration of Government grants in aid from the Board of Agriculture to the Scottish Education Department, the officials of the latter—notably Sir Henry Craik and Mr J. Struthers—had given much consideration to this matter. They were advised by one who had a long and honourable connection with Scottish agricultural education as inspector under both of the departments named, Mr Colin Campbell, of Jura, and they had the wise and helpful guidance of Lord Balfour, who, as Secretary for Scotland, had the complete confidence and respect of his countrymen in agricultural educational affairs as in other matters of national interest.

The Department had then before them the proposals we have mentioned—an Agricultural College for the whole country, a College at Perth, a College at Kilmarnock for the five south-western counties: and they had besides to consider the claims of the existing institutions at Edinburgh, Aberdeen, Glasgow and Kilmarnock.

It would be interesting, but is now futile, to speculate on what the result might have been had the decision been made to found on some central location a great national agricultural college, equipped with worthy buildings and convenient farm land, adequately endowed and maintained, and staffed with the most highly skilled, scientific and practical lecturers and teachers—a Scottish Guelph or Macdonald College. Such a college might have had great capacities of usefulness to Scottish agriculture. On the other hand there are many advantages to students of agriculture, especially in the more advanced stages, in being associated with general University life, and these, to a large extent, would have had to be sacrificed if the above proposal had been carried out.

Whatever the relative merits of the two plans may be, the Department was even then committed to the policy of carrying on existing institutions on the lines of the division of the country into three provinces with a centre of instruction in each. The immediately pressing problem was to obtain some workable scheme for the south-western area, where the agricultural department of the Glasgow Technical College and the Scottish Dairy Institute had already, to some extent, occupied the field, and where there was now this proposal of the five counties for a local college. The Department wisely decided against restricting participation in the new venture to the five counties, and endeavoured to interest the other south-western counties in the proposal; and they further used their influence to have the existing agricultural department and the dairy school included within the consideration of the new scheme.

They accordingly called together a conference of representatives of the following counties:—Argyll, Bute, Dumbarton, Stirling, Renfrew, Lanark, Ayr, Wigtown, Kirkcudbright and Dumfries (together with representatives of the West of Scotland Technical College and the Kilmarnock Dairy School). Sir Henry Craik and Mr J. Struthers represented the Department. The conference was held in the Technical College, Glasgow, on 22nd April 1898, under the chairmanship of Sir Henry Craik. The discussion which ensued showed considerable diversity of opinion, both as to the character of the institution and as to its location, some of the speakers laying stress on the need for practical training, and others emphasising the importance of higher scientific instruction; some advocating the advantages of having college and farm combined, and others insisting on the benefits of association with other branches of science of a University standard. The chairman pointed out that, in order to earn Government financial support, the institution would require to be of a technical and scientific character, but that it ought to be possible to combine work of this description with the more practical form of training which some of the representatives desired. This combination might be reflected in a governing body which would be representative of the two sets of opinions and which might continue the scientific teaching in Glasgow and the practical training at Kilmarnock. If this were done and if the County Councils represented gave their contributions on a generous scale to the support of the institution, the Department would be prepared to deal with it in a similar spirit.

Following upon this conference and further communications with the bodies interested, the Department eventually in May 1899 issued a memorandum embodying the agreement arrived at. This document is sufficiently interesting to warrant quoting it in full. It was as follows:—

Scheme for an Agricultural College for the West of Scotland.

1. An agricultural college to be instituted which shall take

over the functions of the existing teaching institutions at Glasgow and Kilmarnock,

2. The college to be under the management of a body constituted as follows :—

(*a*) There shall be one representative of each Town or County Council contributing annually £50 or such smaller sum as may from time to time be determined, with an additional representative for every £100 contributed.

(*b*) There shall be five representives of the Glasgow and West of Scotland Technical College, while three representatives shall be elected for life by the governors of the present Kilmarnock Dairy School, the entire management of which shall thereupon be transferred to the new governing body.

(*c*) Two representatives of Glasgow University.

(*d*) Two representatives of the Highland and Agricultural Society.

(*e*) Four additional members to be elected by the foregoing.

3. The staff of the agricultural department of the Glasgow and West of Scotland Technical College to be transferred to the new governing body ; the work both at Glasgow and at Kilmarnock to be carried on in such premises as may be found suitable.

4. The new governing body shall be bound to provide, both at Glasgow and Kilmarnock, facilities for instruction in agriculture at least equal to those presently afforded in each of these places, except that they may, at their option, transfer one of the short farmers' courses presently conducted in Glasgow to Kilmarnock, and may further discontinue any form of instruction at either of these centres on its being shown to the satisfaction of the Scotch Education Department that there no longer exists a reasonable demand for that form of instruction at that centre.

5. Instruction in subjects connected with agriculture, but which are not provided for by the regular staff of the college, to be obtained either in the classes of the Glasgow and West of Scotland Technical College (or from lecturers supplied by that institution) or at Glasgow University, or in the case of special subjects not provided for in these institutions in such manner as the Governors shall direct.

6. Further extensions of the work at these or other centres to be at the discretion of the governors, who shall also determine in what manner they shall provide for the management of the various institutions under their charge.

In pursuance of this plan of representation, the different bodies involved were communicated with and invited to appoint their representatives, and in due course a meeting of the elected members took place in the Technical College, Glasgow, on 26th May 1899. Representatives were appointed by the University of Glasgow, the West of Scotland Technical College, the Kilmarnock Dairy School, the Highland and Agricultural Society, and the County Councils

of Argyll, Ayr, Bute, Dumbarton, Dumfries, Kirkcudbright, Lanark, Perth, Renfrew, Stirling and Wigtown. These members thereafter completed the board by electing the four co-opted members. At a subsequent meeting, the Rev. Dr. Gillespie of Mouswald was appointed chairman, and Mr W. Robertson Copland, vice-chairman, while convenerships of Standing Committees were filled by Dr David Wilson, Mr J. W. Stewart and Mr James Johnstone.

The staff of the agricultural department, with Professor Wright at the head, was transferred *en bloc* to the new college, as were also Mr Drummond and his assistants at the Dairy School, while Mr John Cuthbertson was appointed secretary and treasurer.

For some months the new institution was housed in the Technical College, for which accommodation a rent of £100 was paid. This arrangement, however, was merely temporary, and in 1900 the governors purchased the house No. 6 Blythswood Square, which, after alteration and adaptation, was occupied by the college in December of that year The practical teaching at the dairy school continued to be given in the farm dairy at Holmes Farm, and the lectures on dairying theory in the School of Science and Art, Kilmarnock.

The new Board of Governors immediately set themselves to add to the equipment of the college facilities for instruction and demonstration in practical agriculture. In 1900 they leased the farm of Holmes on which the dairy school was situated, and which extended to 200 acres. Their plan was to retain in their own hands 20 acres for experimental work, and to sub-let the remainder to a tenant on condition that he would afford facilities for instruction in the milking and feeding of cows, the rearing of calves and pigs, the weighing and testing of milk, and also for trials and demonstrations of farm implements, tests of manures and seeds, and general insight into farm management. He was to keep and allow access to breed specimens of farm animals supplied to him at commercial prices by the college, and he was to supply manual and horse labour and implements for the working of the experimental section.

Later, consideration was given to the means of providing type animals of the various breeds, and of utilising these for teaching purposes. In connection with this problem, a deputation of governors in the spring of 1908 made a tour of English agricultural colleges which had farms in their occupation, and reported in favour of the college taking the farm into its own hands so that greater freedom of management might be secured. This recommendation was adopted by the governors, and in 1910 the actual working of Holmes Farm was taken over by the governors, the farm to be run in the main as an educational and experimental concern, but with due regard to economical management. The objects to be kept in view were then stated to be—to give a thoroughly practical bias to the instruction by the college staff, to provide pure-bred stock for demonstration and experiment purposes, to serve as a central

station for the experiments conducted throughout the college area, and to afford facilities for instruction in horticulture and supplying seeds and plants for school gardens. The general stock kept and the experiments to be conducted on the stock were to be relative primarily to the requirements of the south-western district, *e.g.*, the breeding of pure-bred Ayrshire stock of a special milking strain and good form, the crossing of Blackface and Cheviot ewes with Border Leicester and other rams, the breeding and feeding of pigs, etc.; and a few specimens of the best-known milking and feeding breeds of farm live-stock were to be kept for demonstration purposes. A section of the farm was to be laid off for horticultural and market garden instruction, and this section was to include a small area under glass.

In 1917 the college leased the adjoining farm of Grange, of 80 acres, bringing the total holding on the two farms up to 270 acres, arable and pasture.

The instruction in practical dairying was carried on in part of the original farm buildings until the summer of 1904, but for some years before it had become evident that the accommodation there provided was inadequate to the growing demand for this branch of the teaching. Negotiations with the other two Scottish Agricultural Colleges, the Highland and Agricultural Society and the Education Department resulted in the recognition of the Kilmarnock school as the National Dairy School for Scotland, and in January 1902 a special committee was appointed to settle upon a site and to take steps for raising funds for building and equipping the new school. A sub-committee visited and reported upon three dairy schools in England—Hutton, Lancashire; Kingston, Derbyshire; and Garforth, Yorkshire—and useful information was obtained for the planning and fitting up of the new school. Donations and grants from private subscribers and public bodies, including the Education Department, were received to the amount of over £4800, and on the 11th June 1904, the school, erected on a site near the college farm buildings, was formally opened by Lord Howard de Walden.

A poultry department was added to the equipment of the school in 1906. Previously, occasional courses of lectures had been given by experienced poultry-keepers and a certain amount of instruction work had been carried on in the counties, but no facilities for practical training had hitherto been available. Following the precedent set in the cases of the farm and the dairy school, the governors appointed a deputation to visit a number of the better-known poultry stations in England, and the new department was established on the lines recommended by the deputation, the expenditure being met by a special grant from the Scottish Education Department.

The college was not long settled in its Glasgow building in Blythswood Square before it was found that the accommodation was insufficient for the increasing numbers of students in attendance, and the question of obtaining premises adequate to the

growing needs immediately became urgent and led to a long continued discussion of different proposals.

Thus in 1902 the governors considered a suggestion for amalgamation with the Glasgow Veterinary College, in whose buildings additional accommodation was offered, the intention being to combine, to such an extent as might be found advisable, those parts of the curricula of the two colleges that could be taught in common. The Veterinary College was not then in receipt of Government grants and the Education Department did not see its way to add to its commitments, and thus the scheme was not carried through. A temporary working arrangement was come to, however, whereby the chemistry departments of both agricultural and veterinary colleges were housed in the Veterinary College and the botany departments in the Agricultural College.

This was a makeshift arrangement, inconvenient to the students and causing loss of time, and the governors eventually decided to extend the college building by erecting a new botany laboratory at the back of the college and providing a new chemistry laboratory on the top flat. The enlarged building was formally declared open by the Secretary for Scotland—the Right Hon. John Sinclair—on 10th December 1906.

It is to be remembered that, as noticed above, the retention of the central classes in Glasgow when the college was constituted was of the nature of a compromise, and all along a number of the Governors had wished the college to be located in the country at a convenient centre for the area, but lack of funds had prevented this project from being entertained. A new phase of the problem was presented when it appeared possible that funds might be available from Government sources. In 1909 was passed the Development and Road Improvement Funds Act, under which grants might be made by the Treasury on the recommendation of the Development Commission in aid of schemes for the development of rural industries. The three Scottish agricultural colleges submitted through the Education Department applications for grants towards the development of their activities. The Glasgow college applied for a grant in aid of (*a*) the provision of a farm and college buildings thereon; (*b*) a research experiment on nutrition; and (*c*) the formation of a forest area.

The case for the new college building was based on the inadequacy of the existing building and the unsuitability of the site. Figures were given indicating the growth of attendance at the central classes, and the consequent lack of accommodation for efficient teaching within the Blythswood Square premises, and it was asserted that efficiency in instruction and supervision, economy in costs, and convenience in working would all be promoted by the erection of a new college on a farm centrally situated for the college area, adapted for purposes of education, demonstration and research, and combining in one building or group of buildings the dairy school and all other departments of the college work. For the purpose mentioned it was estimated

that to purchase the requisite land would cost £15,000, and the erection and equipment of the college buildings £35,000. In the event the Development Commission recommended the Treasury to set aside £60,000 from the Development Fund towards the cost of the schemes put forward by all the three Scottish Colleges, this money to be made available for these schemes up to half their cost, the other half to be met equally by the Education Department and by local contributions obtained by the colleges themselves.

Thereupon in the case of Glasgow ensued a prolonged search for a suitable location; suitable as to character of farm land and suitable likewise in respect of accessibility from all parts of the college area. After much seeking, the governors, or at least a majority of them, concluded that they had failed to find a site which would fulfil all their requirements, and they decided that meantime the balance of advantage lay in the further extension of the Blythswood Square building and the retention of the farm and the Dairy School at Kilmarnock.

This decision was to some extent consequent upon a report made to the Education Department in the spring of 1910 by Mr A. D. Hall, who had been asked by the Department to visit the three colleges and inspect their organisation. In the case of Glasgow, Mr Hall advised that the collegiate building should be retained in Glasgow, that the dairy and poultry establishments should be continued at Kilmarnock, and that a farm for teaching, demonstration and experimental work should be acquired in the neighbourhood of Glasgow. Mr Hall laid considerable stress on the advantage to be gained by both students and staff from association with the university, and he urged the governors not to embark on any scheme, which would involve the creation of a residential college, inasmuch as both capital outlay and maintenance charges in such a case are heavy and the responsibilities of the staff are much increased.

While the question was under discussion certain changes in administration occurred which require to be noticed. In June 1911, Principal Wright was appointed Agricultural Adviser to the Education Department and Director of Operations to the Congested Districts Board, and he then left the service of the college which in large measure owed its origin and successful progress to his energy, enthusiasm and ripe experience of agricultural affairs. In his place the governors appointed Mr W. G. R. Paterson, B.Sc., a former student of the college and then County Lecturer for Dumfriesshire. Principal Paterson took up his duties in September 1911.

Early in 1912 the administration of agricultural education in Scotland was transferred to the newly constituted Board of Agriculture for Scotland which was established under the Small Landholders (Scotland) Act 1911, and of which Sir Robert Wright was the first chairman.

Decision as to the change of policy in regard to the location of

the Glasgow college accordingly fell to be made under the administration of the Board, and on their suggestion a temporary arrangement was come to whereby a four years' lease was taken of the house adjoining the college in Blythswood Square. Eventually, the urgency of providing for the greatly increased enrolment of students which took place in 1918 and succeeding years compelled the governors to acquire this house by purchase, and a remarkably skilful adaptation of the two properties enabled the college by October 1919, to provide class-rooms and laboratories adequate to cope with the larger numbers. Even so, the growing activities of the college in all directions have already outgrown the present buildings and it can hardly be said that the problem of the site of the college is yet finally settled.

Having brought our story of the rise and progress of the college up to the present time we may now take a look at the institution as a working concern and endeavour to obtain some idea of its varied and numerous activities, as these are carried on under existing conditions.

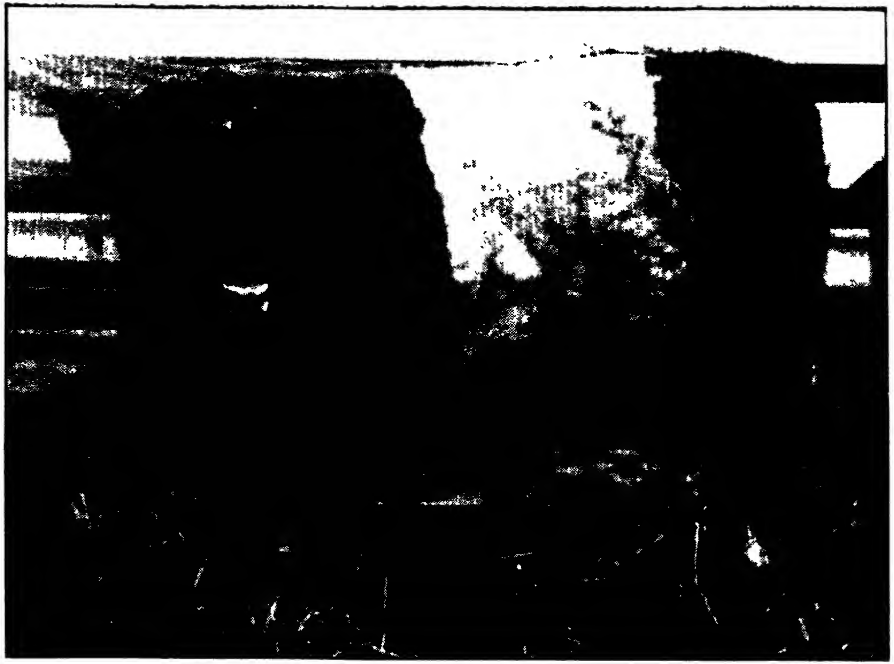
As already indicated, the affairs of the college are administered by a Board of Governors, representative of public bodies in the eleven counties of the south-western province (part of Perthshire being included ; the other part is in the south-eastern or Edinburgh area). Besides Burgh and County Councils, County Education Authorities and County Agricultural Committees are now represented, and the University, the Technical College, the founders of the Dairy School and the Highland and Agricultural Society also have representation on the Board, while the elected representatives have powers to co-opt not more than six other persons to act as governors. For the year 1922–23 the Board of Governors numbered forty-six, of whom Sir David Wilson of Carbeth, Killearn, was chairman ; Mr John M'Caig of Belmont, Stranraer, was vice-chairman ; and the following governors were conveners of committees—Mr Walter W. Blackie, finance ; the Rev. Dr Murray, teaching and staff ; Mr Charles M. Douglas, county work and research ; and Mr Thomas Hunter, dairy, farm and experiments.

Apart from students' fees and sums received for produce sold by the farm and the dairy school, the maintenance of the college is met to a relatively small amount from grants made by local authorities in the college area but mainly from subsidies from Government sources paid through the Board of Agriculture for Scotland, to which body annual estimates are submitted by the governors.

The staff taken over in 1899 from the Department of Agriculture in the Technical College numbered ten and from the Dairy School three. In 1922 the central staff in Glasgow numbered thirty-three, not including four of an administrative section ; the staff at Kilmarnock numbered twenty-four, which figure includes dairy school, poultry department, horticultural department, beekeeping department and farm management. The

GALLOWAY BULL, SQUIRE DACRE (534).

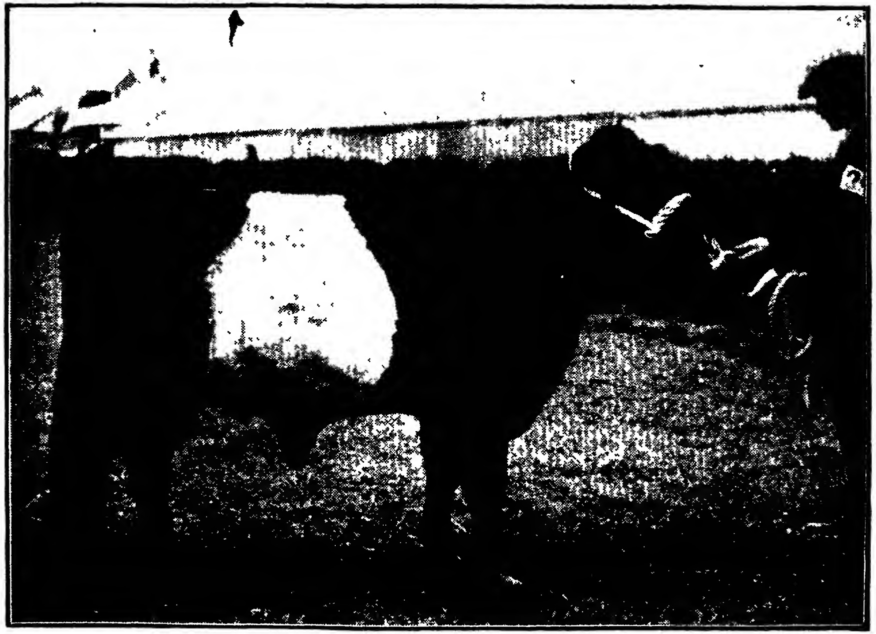
First Prize Aged Bull at the Dumfries Highland Show of 1870. Exhibited with Belted calf by Mr John Fisher, Knells, Carlisle. The above is a photo of the painting by the late Gourlay Steell, R A., in the collection of the Highland and Agricultural Society, by whose kind permission we are enabled to reproduce this picture.



J. C. Brown, Castle-Douglas.

BELTED GALLOWAY BULLOCK.

First in his Class and Reserve Champion at Castle-Douglas Christmas Show, December 11, 1922.



C. Reid, Wishaw

BELTED GALLOWAY BULL, KNOCKBREX POLLUX.

One Year, Four Months. First in his Class at the Highland and Agricultural Society's Show, Dumfries, 1922.

(The blocks for this and the preceding illustrations have been kindly lent by the *North British Agriculturist*)

C. Reid, Wishaw.

BELTED GALLOWAY COW, HALMYRE BESS.
First and Reserve Champion. Highland Show. Dumfries, 1922.

extension staff numbered twenty-four. Thus the total staff has increased from thirteen at the commencement of the college to eighty-five at the present time.

At the Central College in Glasgow the main part of the work of the staff is the teaching of the subjects which are included in the curricula for the various qualifications offered by the college or by other authorities, The most important of these is the University Degree of B.Sc. in Agriculture which was instituted in 1897 under an arrangement between the University and the College, whereby certain of the subjects necessary for graduation were to be taught in the college on condition that the lecturers giving these courses should be recognised by the university. The appointment of the professor of agriculture was thereafter to be made jointly by the two bodies. The course for the B.Sc. Degree is usually spread over four sessions, of which the first two are taken at the university and the third and fourth mainly at the college. The curriculum for this degree is at present being revised.

The College Diploma in Agriculture and the National Diploma in Agriculture are taken by a large number of students, and the classes necessary to cover the ground for these qualifications are all given in the college and are practically the same for both. The course is one of three winter sessions.

In a shorter course of two winter sessions the College Associate qualification may be taken; and a special one winter session course is given under the title of the Farmers' Course.

By combining attendance at classes in Glasgow during the winter session with attendance at practical and theoretical classes at Kilmarnock in the summer session, students may obtain the College Diploma, or the National Diploma in Dairying and the College Diploma in Horticulture; while junior, senior and advanced courses in poultry-keeping, and similar courses in bee-keeping are available at Kilmarnock, where also by arrangement shorter special courses may be obtained in dairying, poultry-keeping or bee-keeping.

During the winter session in Glasgow a useful set of evening classes is held in agriculture, horticulture, poultry-keeping, bee-keeping, agricultural law, book-keeping, chemistry, botany, zoology and geology.

It is not possible to give here details of these different courses of study offered by the college; they can be learned from the college calendar; but it is obvious from even this brief resumé that the needs of all types of students are catered for. The classroom and laboratory instruction is greatly strengthened by demonstrations at Holmes and Grange farms and at other typical farms to which excursions are regularly made by students and staff during the session.

In enumerating the courses given by the college, mention should be made of the special courses arranged for disabled ex-service men. The intention was to give these men a training

such as would fit them either to become small-holders or to act as handy men about a farm or an estate. The training period varied from three months to a year and included instruction in agriculture, horticulture, poultry-keeping, pig-rearing and bee-keeping, with some practical training in these lines and also in carpentry. Special arrangements were made to accommodate these men on Grange Farm where separate equipment for teaching practical work was provided. From February 1919 when the training began to April 1922 when it was brought to an end, over one hundred ex-service men went through this course.

Besides the teaching carried on at the Glasgow and Kilmarnock centres, there has always been a considerable amount of experimental and research work conducted by the central staff on problems of special interest in the college province, such as the comparative merits of different varieties of cereals and roots, the manuring of crops, the destruction of weeds, the treatment of crop diseases and the feeding of farm stock. The results of this work are embodied in reports which are issued as a rule annually, the latest being the seventeenth—issued in 1921.

Research work has been carried on for some years under special grants from the Development Commission and the Board of Agriculture for Scotland. An investigation by Professor Berry into the feeding of dairy cows and the effect of changes of food on the composition of milk has produced interesting results; cheese-making and butter-making problems have been investigated by Professor Leitch and his assistants; and a soil survey of the college area has been undertaken by Mr Monie.

This experimental and research work is concomitant with the giving of advice to individual farmers on particular problems met with in their operations, including such matters as the examination of seeds, the identification of plants, the diagnosis and treatment of crop disease attacks, the examination of milk, and other problems of the farmer or gardener, the dairyman or poultry-keeper.

This particular line of work has recently been put upon a more permanent footing by the appointment of three advisory officers whose main duties will be investigation into local problems and the giving of advice to farmers. The governors have selected, as the branches of agriculture most likely to benefit from work of this kind, dairy husbandry, utilisation of milk and plant pathology, and each of the officers will devote himself to work in one of these departments.

The extension work of the college includes systematic instruction in the various branches of agricultural science, horticulture, dairying, poultry-keeping and bee-keeping; courses of lectures or single lectures on subjects of special interest in the locality; experimental work, including demonstrations, lectures and the publication of reports on results; visiting and advising farmers, small-holders, poultry-keepers, cottagers, allotment-holders, bee-keepers and others; visiting and inspecting poultry stations from

which sittings of eggs are distributed under the schemes of the Board of Agriculture for Scotland; giving instruction and advice in connection with school gardens.

On the extension staff there are twelve instructors in agriculture, eleven instructresses in dairying and poultry-keeping, four lecturers in horticulture, two in bee-keeping and one special instructress in poultry-keeping. One instructor and one instructress are posted to each county for which the instructor acts as agricultural organiser. The other lecturers cover the whole college area.

As a means of interesting the agricultural community in the work of the college and of spreading of information, demonstration areas and demonstration crofts have proved remarkably successful. Last season, there were eight demonstration areas in operation in different parts of the college province. Each area extends to eight or ten acres. The usual rotation of the district is followed: certain plots are treated according to local practice; others according to methods recommended by the college as modifications of existing practice; and the farmers in the neighbourhood are invited to attend at convenient times to inspect the results and to discuss the procedure with the college representatives.

Two demonstration crofts are dealt with on similar lines in crofting districts; while four other crofts are run with the special purpose of showing modern methods of poultry-keeping. Houses and appliances of good type are used and pure breeds of fowls are kept. Records of costs and income are kept and local poultry keepers are encouraged to inspect the holdings and books and to discuss methods of management.

Besides the work carried on at these areas and crofts, field experiments are arranged on selected farms in all the counties, and these also are used at appropriate times for demonstration lectures to those interested.

This rapid review of the college activities does not profess to be exhaustive, but it may serve to indicate the wide scope of the work and the varied nature of the duties of the staff, as well as to give some hint of the possibilities of even greater development.

BELTED GALLOWAYS.

SIR H. ARTHUR ROSE, D.S.O.

IN considering the various breeds of live-stock in Scotland it may seem redundant to deal with Belted Galloway cattle in a special article when Galloway cattle have already formed the subject of an interesting contribution to the *Journal*, but as circumstances have compelled those interested in Belted Galloways to form an independent society for that variety, they may now be fairly classified as a distinct breed of Scottish pure-bred live stock.

In many ways it is to be regretted that one Galloway Society could not have undertaken the care of the various varieties of

Galloway cattle, in view of the fact that blacks with white belts, Duns with white belts and Duns are obviously as old as the more usual all-black variety. If evidence of this is required, reference may be made to David Low in *Domesticated Animals of the British Islands* (*1845*), who, in discussing the now extinct sheeted or belted breed of Somerset, says :—"The peculiar marking which distinguished these cattle is not confined to any one breed. It appears amongst the cattle of Wales when crossed with the White Forest breed : it is frequent among those of Ireland, and used to be so among the older Galloways of Scotland."

Mention might also be made of the painting by the late Gourlay Steel, R.A., in the collection of the Highland and Agricultural Society portraying the first prize aged Galloway bull at the Highland Show at Dumfries in 1870, with belted calf.

As events have developed, however, the Belted Galloway is now established as an independent breed of Scottish cattle, with its own Society to look after its interests, and thus an ancient, useful and picturesque breed of cattle will be catered for to the national advantage.

It is claimed that the Belted Galloway is a true Galloway, and its original range is found to have coincided with that of the Blacks, viz., South-West Scotland and North-West England, and the general characteristic of all Galloway cattle, viz., hardiness, is an outstanding attribute.

Development of the Breed.—It is not possible in the case of the Belted Galloway to point to outstanding breeders who, in the old days, were pioneers in developing and fixing the breed, in fact it may almost be said that the particular variety under discussion persisted in spite of neglect and even active antagonism.. In more recent times, however, the foundations of the present development were laid by several gentlemen whose names must be recorded, viz., Mr George G. B. Sproat of Borness, the late Mr James Brown of Knockbrex and Mr Robert Graham of Auchengassel. Mention should also be made of the Melville herd, which was founded about 150 years ago by Lady Melville of Featherstone Castle, Haltwhistle, by drafts from the Earl of Selkirk, Balmas, Kirkcudbright. Descendants of this fine old strain are still to be found in the Haltwhistle district, and to a certain extent in the Knockbrex herd.

To Mr George Sproat must be given the credit of being the most important "improver" in modern times, and undoubtedly his work, following upon that of his father, which commenced in 1848 at Almorness, near Dalbeattie, has been vital in preserving this breed.

The Belted Galloway as Found To-day.—The modern Belted Galloway is a close approximation to that ideal, the dual purpose animal. The breed shows all the beef characteristics of the Black Galloway, and, in addition, produces milkers of a high order. It may be permissible to give a few instances of both attributes.

In 1905 a dun belted bullock, bred by Mr Robert Graham of Auchengassel, was exhibited by him at the Scottish National and

Smithfield Shows. At the former he was first in his class, Champion Galloway and Champion of Show for animals under two years, also winning the Ardross Cup. At the latter he was Champion Galloway, and at this time weighed 12 cwt. 3 qr. 16 lb. In 1906, as a three-year-old, he was Champion Galloway and Reserve Champion at the Scottish National, and at Smithfield was Champion Galloway.

One more instance of beef qualities must suffice. Eight Belted Galloway bullocks, bred by Mr Graham of Auchengassel, were sold to Mr James Craig of Cunning Park, Ayr, in October 1921, when slightly over two years old. They had always been outwintered, and up till January 1922 got nothing but what they pulled. From that date till they were sold on 25th August 1922, they got little extra feeding. These bullocks weighed in all 100 cwt. 2 qr. 7 lb. live-weight, 58 cwt. 3 qr. 20 lb. dead-weight, and dressed 58·59 per cent.

Turning now to milking qualities, it should be mentioned that the Belted Galloway has long been considered a valuable milker on many an upland farm in Galloway, where one or two cows only are kept under somewhat adverse conditions. We have, in addition, much valuable information from the herd of the late Mr James Brown of Knockbrex, where careful tests have been made for a considerable number of years, In 1918–19 the herd average was 743 gallons, at 4·55 per cent. butter fat, and individual cows have yielded over 900 and 1000 gallons in a lactation period. As further proof of the duality of purpose of the breed it is worthy of record that the Dun bullock mentioned above as Champion Galloway at Smithfield in 1906 was uterine brother to "Dairy Maid" of the Knockbrex herd, which gave over 1000 gallons in each of two lactation periods when sixteen and seventeen years old.

Breed Characteristics.

Colour.—Black, with brownish tinge and white belt, or dun with similar markings.

The belt should extend from behind the shoulders to the hooks, and half the udder should be white.

Head.—Wide, moderately long from eye to muzzle. Forehead wide, nostrils wide.

Eye: Large and prominent.

Ear: Moderate in length and broad, pointing forwards and upwards, with fringe of long hairs.

Neck.—Fairly long, clean, fine at its junction with head filling well into shoulders, the top in line with back in female and in a male rising with age.

Body.—Deep, rather wedge-shaped.

Shoulders: Fine and straight, not too wide above.
Breast: Full and deep.
Back and Rump: Straight.
Ribs: Well sprung and deep.
Hook Bones: Fairly wide.
Hindquarters: Long.

Flank.—Deep and full.
Thighs.—Rather thin, deep and fairly straight.
Legs.—Short and clean, with fine bone.
Tail.—Well set on, thin.
Skin.—Mellow and moderately thick.
Hair.—Soft and wavy, with mossy undercoat.

A good cow of the breed has a nicely-shaped udder, well gripped up behind and extending well forward, with four evenly planted teats of a good size. The milk veins are prominent, and extend well forward on the belly.

A quiet even temper is also a natural characteristic of the breed, the cows being very docile and easily milked. A nice broad escutcheon and a thin tail terminating in a switch of fine soft hair is usual.

Herd-Book.—As already mentioned a Society has now been formed to care for the interests of the breed. This Society is designated "The Dun and Belted Galloway Breeders' Association." At the time when this body was in course of formation, Dun Galloways as well as Belted Galloways were excluded from the Galloway's Society's Herd-Book, but have since been readmitted.

The Association consists of over forty members, and Volume I. of the Herd-Book which is now completed, contains 330 entries, representing 18 Dun Bulls, 114 Dun Cows, 48 Belted Bulls, 140 Belted Cows and 20 animals in the appendices.

Admission to the Herd-Book has been granted only after careful investigation and inspection, and it may fairly be said that a conservative but sound foundation for the breed has been laid.

In conclusion, it falls to be recorded that the Belted Galloway has taken its place along with the other breeds in the Highland Society's Show, and it is hoped that from now on this useful animal will form one of the distinctive breeds of pure-bred live stock, which do so much to make the Scottish stockbreeders famous the world over.

POULTRY KEEPING ON THE FARM.

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Lecturer in Farm Economics, University of Leeds.

FOR many years the Department of Agriculture of the University of Leeds has been making a careful study of the economic position of agriculture in the county, and with that object has been examining, closely and in detail, the accounts of a large number of Yorkshire farmers. At the present time fifty-two farms with an area of approximately 13,000 acres are under observation in every part of the county; farms varying in size from small holdings of 16 acres to wold farms of over 1000 acres, and varying in type so as to include, as far as possible, every one of the varied systems of farming to be found in the county.

When on the whole of these farms last year there was an average loss of £2, 10s. 6d. per acre, a loss equivalent to 16 per cent. of the capital invested, or to 1·9 times the rental, it is exceedingly gratifying to be able to state that only one single case has been met with where the keeping of poultry and the production of eggs was not a paying concern.

On the whole of the farms—ordinary commercial farms, not one of which could technically be called a "poultry farm"—the birds left an average profit of 13s. 4d. per head. On one farm where the poultry were under the control of the daughter of the farmer—himself a successful man with marked business instincts which he had undoubtedly transmitted to his daughter—a profit of just over £2 per bird was realised, and more than £400 so made was invested for her.

Evidently, therefore, at the present time the keeping of poultry is a useful and profitable side-line, and at times like these when, so far as the farmer is concerned, every penny is of importance, it seems a pity that more attention is not given to this branch of the farming industry.

Why Poultry Keeping is Profitable. *Selling Price.*—That poultry keeping at the present time should be profitable is self-evident, and would be obvious were there no authenticated records to prove it. A study of the market returns will show that the price of poultry and eggs is being maintained better perhaps than that of any other farm product.

TABLE I.

PERCENTAGE INCREASE IN SELLING PRICES 1922, AS COMPARED WITH THOSE IN CORRESPONDING MONTHS 1911-13.

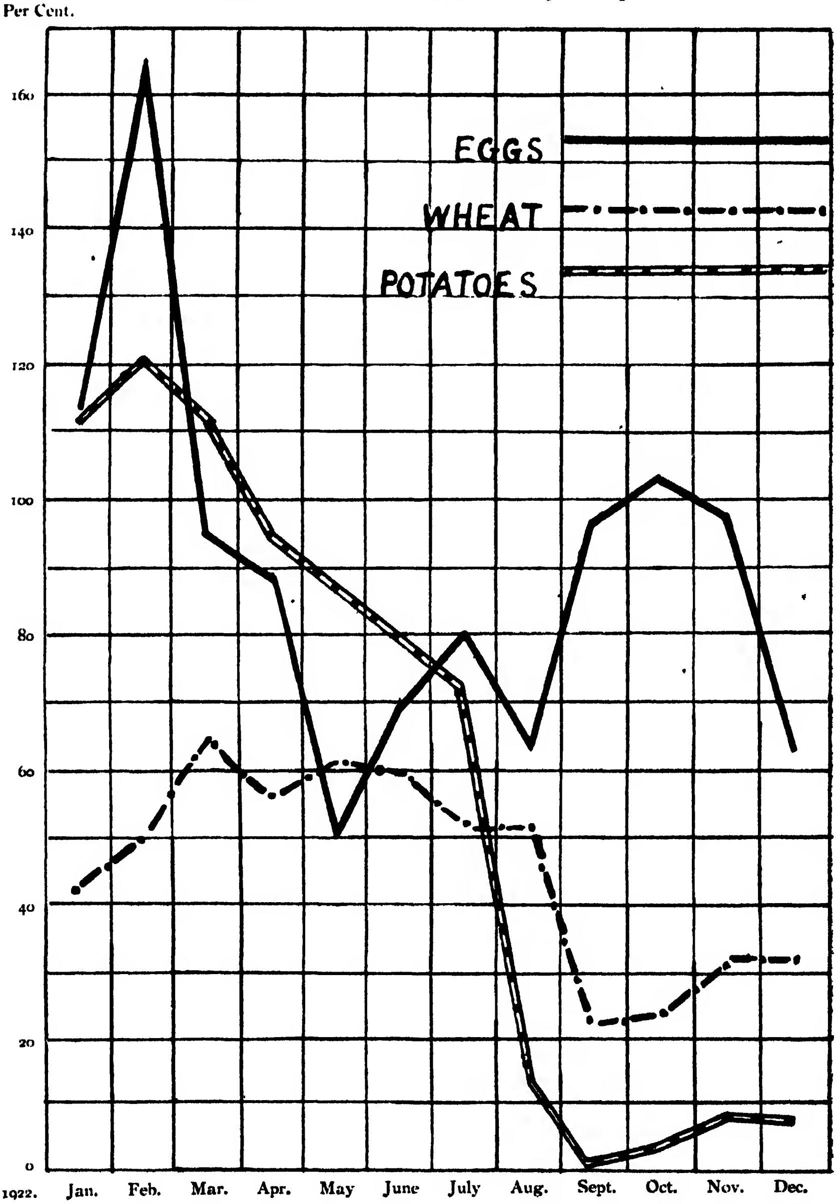
	Eggs	Poultry	Wheat	Barley	Oats	Potatoes	Hay
1922	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
January . .	114	76	44	51	49	113	35
February .	166	80	50	49	48	122	32
March . .	95	77	66	46	53	112	32
April . .	89	83	57	49	49	95	28
May . .	50	110	62	49	53	140	33
June . .	69	116	60	58	57	80	35
July . .	80	103	53	49	52	72	37
August . .	64	85	53	48	59	14	54
September .	96	85	23	26	31	1	52
October .	104	77	24	29	33	3	45
November .	98	75	32	34	38	8	45
December .	63	86	32	17	36	7	47
AVERAGE	91	88	46	42	46	64	40

Cost of Production.—Of the total cost of upkeep of fowls at least 80 and in many cases 90 per cent. can be charged to the food bill. If we compare the present prices of the food stuffs largely fed to poultry, such as wheat, oats, barley, maize, maize gluten-meal, sharps, bran and fish meal with the prices obtaining

immediately prior to the war, it will be found that there has been an increase of approximately 40 per cent. In other words, while

FIG. I.

MOVEMENT OF PRICES OF AGRICULTURAL PRODUCE PERCENTAGE OVER THE AVERAGE FOR 1911–13.



the selling price of eggs and poultry was last year approximately 90 per cent. above the pre-war level, their cost of production was little more than 40 per cent. higher. In this respect eggs and

poultry differ very considerably from most of the other farm products. The cost of production of the 1922 wheat crop was at least 85 per cent. above that of the 1914 crop, yet to-day's selling price is only 32 per cent. above the corresponding price for the 1914 crop.

The selling price of potatoes is to-day less than the corresponding pre-war figure, while their cost of production is approximately 100 per cent. higher.

Why the Price of Eggs has been Maintained. *Home Production.*—While the poultry returns are not included each year in the agricultural statistics collected by the Ministry in June, yet estimates have been obtained by them for the number of poultry on the farms in England and Wales for the years 1908, 1913 and 1921. These estimates show that in spite of the high prices now obtaining for eggs and poultry, the number of birds being kept has during the past eight years decreased by more than four millions.

TABLE II.

NUMBER OF POULTRY ON FARMS IN ENGLAND AND WALES.

	1908	1913	1921
Fowls	28,249,000	29,026,000	24,816,000
Ducks	2,669,000	2,188,000	2,391,000
Geese	686,000	577,000	517,000
Turkeys	628,000	652,000	445,000

Throughout England and Wales to-day the number of poultry carried amounts only to 95 per 100 acres of cultivated land as compared to approximately 200 birds to the same area in Denmark. This figure is well below the one which was obtained in 1913, when each 100 acres of cultivated land carried 107 head of poultry. Of the six counties, Lancashire, Cheshire, Cornwall, Surrey, East Sussex and the West Riding of Yorkshire, which may be looked upon as the great poultry-keeping areas, only one has increased the number of birds kept since 1913. On the other hand, the Scottish poultry keepers appear to have been more alive to the possibilities of the situation, for in Scotland the number has increased from 90 per 100 acres in 1913 to 96 in 1921, the numbers in several counties showing large increases. This is notably the case in Orkney and Shetland, where a new market was provided by the establishment of the Naval Base at Scapa, and where also co-operation in the marketing of eggs has reached a high standard. Aberdeen, Banff, Inverness, Ayr and Bute also showed marked increases.

Imports.—Not only has the number of fowls in the country fallen by over 11 per cent., but the imports have also dropped by more than 52 per cent. In 1913 when we were importing fifty-seven eggs per head, more than half of these were coming from Russia and approximately one-fifth from Denmark, while the Netherlands,

Italy, Austria-Hungary and Egypt were each sending more than a hundred millions, and Germany, France and Sweden amounts varying from 48 to 84 millions. Russia ceased to export in 1916;

TABLE III.

EGGS IMPORTED.

Year	No.	Value	Per Head of Population
1913	2590 millions	£9,600,000	57
1914	2149 "	8,653,000	48
1915	1229 "	6,123,000	26
1916	793 "	4,742,000	17
1917	591 "	5,067,000	12
1918	318 "	4,622,000	7
1919	677 "	8,613,000	14
1920	847 "	11,569,000	18
1921	1264 "	11,393.000	26
1922	1639 "	12,000,000	33

FIG. II.

IMPORTS OF EGGS PER HEAD OF THE POPULATION.

Germany, France, Italy and Austria-Hungary no longer send us any appreciable number. During the war the supplies from Denmark fell from 511 to 141 millions, but with the German market closed in 1920, owing to the exchange being so greatly against her, Denmark again started developing the English trade, and in 1921 she sent us no less than 568 millions. Egypt has throughout been sending a large and constant supply, Canada and the United States started exporting in 1914, though our imports from the United States in the last two years have been remarkably small. One of the most striking features of our imports of eggs in 1921 was the way in which many new attempts were being made to gain the English market. From the newer states we imported 78 millions from Czecho-Slovakia, 52 millions from Latvia in the Baltic provinces, and 22 millions from Poland, while the Argentine sent us over 60 millions.

With the home production of eggs down at least 11 per cent. and imported eggs down 52 per cent., the demand was bound last year to be in excess of the supply, with a constant stiffening in price.

With the many new competitors for our English market, and with the possibility of the recovery of Russia, it behoves the English farmer to make every attempt to hold our own markets in a branch of production in which the ordinary farms should be able adequately to supply the home demand.

This can be done only if—

(*a*) A much larger head of poultry is kept on the farms.

(*b*) More care and attention is given to the production of eggs.

Number of Poultry on the Farms.—It has already been pointed out that at the present time throughout England and Wales the number of poultry carried amounts only to 95 head per 100 acres of cultivated land as compared with approximately 200 head on a similar area in Denmark.

The 1913 statistics collected by the Ministry show that it is the smaller farms and holdings which are heavily stocked as far as poultry are concerned.

TABLE IV.

VARIATION WITH SIZE OF HOLDINGS.

Size of Holding	No. of Poultry in 1913
1-5 acres	993 head per 100 acres
5-20 „	392 „ „
20-50 „	193 „ „
Over 50 „	69 „ „

Our own observations in Yorkshire go to show that the larger the farms the smaller the proportionate number of poultry kept; farms of over 500 acres carrying not more than twenty birds per 100 acres of cultivated land.

There is no doubt, therefore, that the number of poultry maintained on the farms could and should be materially increased.

Possible Increase of Profits from Present Stocks.—In a very interesting report[1] of the Poultry Demonstration Croft, Littleton, Crieff, Miss Mary Young shows that an average profit of £2, 7s. 2d. per bird was obtained during the year ending 30th September 1921. The most striking thing about the report is the high production of eggs obtained—an average of no less than 216 per head. This is interesting as showing what can be done when a good laying strain has been obtained, and they are managed and fed with judgment. There is no doubt that the main essential of success in poultry keeping is to get eggs, and plenty of them.

TABLE V.

YORKSHIRE FARMS, 1921–22.

	No. of Eggs Produced per Bird	Profit per Bird
Farm 1 . . .	186	£2 0 4
" 2 . . .	152	1 6 3
" 3 . . .	114	0 17 0
" 4 . . .	96	0 18 4
" 5 . . .	78	0 8 8
" 6 . . .	74	0 7 4
Average of all farms	90	£0 13 4
Farm 7 . . .	55	Loss £0 0 7½

In the case of Farm 7, with an egg production of only fifty-five per bird, the net loss amounted to 7½d. per bird. As the eggs were sold throughout the year at an average price of 2½d., it meant that the poultry would have paid their way with an average of 58 eggs per bird.

If we take Miss Young's birds as having an efficiency of 100 per cent. last year, birds with an efficiency of 27 per cent. could have paid their way. In no other branch of the farming industry could such a result have been obtainable.

To get a good supply of eggs the birds—

(*a*) must be kept clean,
(*b*) must be given plenty of exercise,
(*c*) must be young, and should certainly not be kept more than two years,
(*d*) must be fed well but not too well—within the limits of from 3 to 4 oz. per head per day,
(*e*) must receive in their daily ration a sufficient supply of protein, certainly not less than half an oz. per day,
(*f*) must come from a good laying strain.

[1] *See* this *Journal*, October 1922, p. 418.

On the average farm possibly no branch of stock gets less attention than the poultry: little trouble is often taken with the strain, they are frequently kept on the farm too long, sometimes over-fed, often under-fed, and rarely get in their food supply the protein ration they require for heavy egg production.

Of the foods rich in protein fish meal, dried yeast, maize gluten meal, meat meal, meat scraps or even palm kernel are all suitable for feeding to poultry, and in every case that we have met where high egg yields have been obtained one or other of these foodstuffs has been fed.

Miss Young fed 1 oz. of mixed grain in the litter in the morning, 2 oz. of dry mash during the day, and 1 oz. per head of mixed grain as last feed—4 oz. per head per day.

The grain consisted of—		*The dry mash of—*	
Oats	1 part.	Bran	2 parts.
Wheat	1 „	Sharps	2 „
Indian Corn	1 „	Indian Meal	2 „
		Crushed Oats	2 „
		Fish Meal	1 part.

The 4 oz. feed each day supplied 0·47 oz. of protein, and she got the eggs.

Phillips in 1918 feeding Plymouth rock pullets on grain and a mash of bran and sharps got 61 eggs per bird, with the addition of meat scraps to his mash the egg production was increased to 136 per bird.[1]

The food fed to the poultry on Farm 2, with an average of 152 eggs per bird, was a mixture of wheat, barley, sharps, bran, Indian meal, fish meal and palm kernel meal, allowed for an average daily ration of 3·47 oz. per head, and supplied 0·42 oz. of protein per head per day.

The food fed to the poultry on Farm 4 with an average of 96 eggs per birds consisted of a mixture of wheat, barley, uveco, maize, sharps, bran and Paisley meal, and allowed for an average daily ration of 4·46 oz. per head, but supplied only 0·34 oz. of protein per head per day. Here, undoubtedly, the birds were overfed, with a ration not sufficiently nitrogenous, and the birds were putting on weight rather than producing eggs.

In the case of Farm 7, where the egg production only amounted to 55 per bird, the food consumption allowed for a ration of

0·3	oz. of	wheat	per head	per day,	supplying	0·03	oz. protein
0·4	„	oats	„	„	„	0·03	„
0·6	„	sharps	„	„	„	0·08	„
1·2	„	maize	„	„	„	0·08	„

or a total of 2½ oz. of grain and meal, supplying less than a ¼ oz. of digestible protein. On such a ration it was impossible for the hens to lay.

[1] *See* this *Journal*, Vol. V., No. 2.—"The Feeding of Hens," by D. W. STEUART, p. 157.

In the case of Farm 1, where the egg production amounted to 186 eggs per bird, the dry mash consisted of—

Fish Meal . .	1 part.	Ground Oats .	1 part.
Sharps . . .	1 "	Dried Yeast .	$\frac{1}{4}$ "
Maize Gluten Feed	1 "		

and the grain of a mixture of equal parts of wheat, oats and maize, and the food consumption allowed for a daily ration of just over $3\frac{1}{2}$ oz. per head, supplying 0·48 oz. of protein.

There is no doubt that with the expenditure of care, thought and trouble, the returns obtainable from poultry, under ordinary farm conditions, can be considerably increased. To take only one example, on one farm (No. 8) where 120 birds were kept, the total profit from the poultry amounted in 1919-20 to £36, 11s. 6d., an average of 6s. per head.

The relatively low profit could be accounted for in one of three ways.

(*a*) The eggs might possibly have been sold in a bad market and fetched a low price.

(*b*) The fowls might have been laying badly, so that there was little produce to sell.

(*c*) The cost of upkeep of the birds might have been too high, and high costs might have cut down the profit.

On turning to the account it was seen that 10,691 eggs were sold for £176, 18s. 8d., at approximately 4d. each. It was evidently not the market which was at fault, and little hope could be entertained of increasing the profits by increasing the selling price of eggs. The sale of eggs allowed for an egg production of only eighty-nine eggs per bird. Here surely was room for improvement.

TABLE VI.

FOOD CONSUMPTION BY POULTRY ON FARM 8. 1919–20.

	Total	Per Head per Day	Protein per Head per Day
Wheat . .	56 cwt.	2·3 oz.	0·198 oz.
Barley . .	35 "	1·4 "	0·064 "
Oats . . .	16 "	0·6 "	0·042 "
Maize . . .	5 "	0·2 "	0·014 "
Sharps . .	3 "	0·1 "	0·014 "
Biscuit Meal .	2 "	0·1 "	0·008 "
TOTAL .	117 cwt.	4·7 oz.	0·34 oz.

Was the low egg-production due to the fact that the birds came of a bad strain, were they too old, or was there something wrong with the feeding? Many of the old birds could certainly with advantage be replaced, and have been, by pullets.

The total weight of corn and meal consumed by the poultry amounted to 117 cwt., which allowed for a consumption of 109 lb. per head per year, or 4·7 oz. per day. The total cost of food amounted to £150, 10s. per year; £1, 5s. 1d. per head, or 5½d. per head per week.

Allowing for labour and standing charges, the total cost of upkeep per bird amounted to no less than £1, 11s. 1d. per year, much too high a cost. If the food could be reduced as it should be from 4·7 to 4 oz. per head per day, it would have reduced the cost of upkeep by approximately 5s. per bird. If the egg production could at the same time, by modifying the constituents of the ration, be increased from 89 to 120 eggs per bird, it should give an increased return of approximately 10s. per head, and the profits per bird could be increased from 6s. to 21s. per head, or from £36, 11s. 6d. to a total of £126.

By weeding out the old hens, and by feeding in accordance with the suggestions that have already been made, the egg production per bird has been increased from

89	in	1919-21
to 108	„	1920-21
and to 126	„	1921-22;

the cost of upkeep per bird has been reduced from

£1	11	1	in	1919-20
to £1	0	8	„	1920-21
and to £0	12	7	„	1921-22;

while the profit per bird has been increased from

£0	6	0	in	1919-20
to £0	18	6	„	1920-21
and to £1	6	11	„	1921-22

Summary.—In conclusion it may be stated that—

(*a*) As far as can be seen the keeping of poultry should, at the present time, prove one of the most remunerative side lines on the farm.

(*b*) That on the Yorkshire farms, whose accounts were last year supervised through the University of Leeds, there was an average profit of 13s. 4d. per bird.

(*c*) That the high profit has been obtained owing to the fact that while the selling price of eggs was on the average 91 per cent. above the pre-war prices, the cost of production was only 40 per cent. higher.

(*d*) That the high price of eggs has been maintained, because with the home production of eggs down at least 11 per cent. and the imported eggs down at least 52 per cent., the demand was almost bound to be in excess of the supply.

(*e*) That the profits obtained from poultry could easily be increased:

1. By increasing the number of birds on the farm.
2. By increasing the egg production per bird.

(*f*) That the egg production per bird could, in many cases, easily be increased by attention to the feeding of the poultry, and arranging that the daily ration should provide:

1. 3-4 oz. of grain and meal per head per day.
2. Approximately ½ oz. of digestible protein per head per day.

FARM PESTS.[1]

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Mammal Pests—continued.

(3) DESTROYERS OF WOODS.—The farmer, in his own sphere of tiller of the soil and stock-raiser, may have no large interest in the planting and growth of timber, yet many farms have their woodlands and most have their ranges of shelter-belts or their shelter-clumps, upon the successful growth of which the highest productivity of the farm depends. The pests of woods and their control have, therefore, more than a casual interest for the farmer.

Domestic Animals.—The development of woodland is a thing so different from the ordinary operations of the farm that a curious situation arises, for the presence of domestic stock upon which the farmer lavishes his care is inimical to the growth of trees, and in this respect, his cattle, sheep and goats take their stand along with the natural pests. This is especially true in the case of new plantations and of natural or artificial woods the persistence or expansion of which is left to the agency of nature. In natural conditions the maintenance of a forest is due to the constant springing up of seedlings in the humus, each ready, should opportunity be offered by the decay and collapse of some old giant of the woods, to push towards the light and fill the temporary gap in the forest. This natural development is brought to a full stop by the introduction of sheep, which, even if they confine themselves to herbage during the greater part of the year, are driven in winter to browse upon any available food supply, with the result that the seedlings are grazed to the ground, and, natural repair being cut off, the forest decays without hope of replacement.[2] Not only have actual instances of such destruction been observed in recent years in Scotland, but the danger of the promiscuous pasturing of flocks in the woods has been recognised here since the middle ages, when laws were passed (*Leges Forestarum*) imposing penalties upon flocks found straying in the forests. So, also, at the

[1] Earlier articles of this series appeared in this *Journal* for July and October 1922, and January 1923.

[2] For a detailed account of the influence of sheep on Scottish forests see an article by the writer on "Some Effects of Sheep-rearing on the Natural Condition of Scotland" in this *Journal*, April 1919, p. 190.

present day in Norway, the gradual retreat or disappearance of pine-woods in the neighbourhood of farms is attributed to the trampling and browsing of domestic animals.

Sheep and cattle alike share in this destructiveness; but owing to their distribution and their larger freedom of movement, the greater danger to Scottish native forests arises from sheep. Goats are probably more destructive than either; it has been stated that the passing of a herd of goats is as ruinous to young trees and shrubs (in Tunisia) as a bush fire, and in the native pine-woods of Portugal I have seen the herded goats making a practice of clambering to their full height on young trees to browse upon the tender, growing shoots and leaves. But goats are not so plentiful in Scotland as they once were, though it is well to recognise that where they are allowed to roam freely, as in many upland areas, their influence upon forest development is bound to make itself felt.

Although reference has been made mainly to native forests, the interference of domestic animals is, of course, not confined to these, but plays its part wherever domestic animals obtain access to woods. Young plantations are bound to suffer most heavily, for equal damage there has a relatively greater effect; but the fact that, during the present winter, I noted several ancient beeches in Aberdeenshire barked and girdled by a few Shetland ponies, shows that the older woods may not escape.

The obvious and the only means of preventing such destruction as has been described is by the rigid exclusion of domestic animals from young plantations, as well as from old and valued timber areas where reliance is placed upon natural regeneration for the maintenance of the forest; and this cure necessitates the erection or upkeep of the appropriate barriers, fences, dykes and the like.

Deer.—Deer, whether they be Red Deer, Roe or Fallow, belong to a race of animals whose original home is the forest, and this they still exclusively frequent in those European countries where civilisation has not yet ousted them from their natural habitation. The leaves and shoots of trees and bushes are, therefore, a natural food of the various species, to which, when the choice offers, they turn in preference to herbage, favouring the tender growths of beech, hazel, alder and such like. It might seem that in Scotland deer exist very largely beyond the forest area, but this is not so, for Roe Deer haunt the forest, while in winter most Red Deer descend into the shelter of the woods, and even in summer, when the harts seek the higher parts of the hills, the hinds and fawns prefer the lower forest-clad valleys.

The woodland damage done by deer is exactly comparable to that caused by domestic animals, and consists particularly in the destruction of seedlings and young trees by browsing. There is no effective method of protecting such forest growth, except by the expensive and in many cases impracticable method of confining deer to their proper territory by the erection of strong and high deer-proof fences.

The Red Squirrel.—The common Red Squirrel, liveliest and most graceful of our woodland creatures, needs no introduction. Its brownish-red body, white on the under surface, its erect ears, with their spring-time tuft of hairs, and particularly its long and bushy tail, now adding to the balance of the creature as it climbs, helping in a long glide, or simply curled snugly about its back as it rests, are features which unite with an unusual activity of habit, and a marvellous dexterity of movement on the slender foothold of the tree-tops, to give the squirrel a place of its own in the eyes of the people. It has also created for itself a place of its own in the eyes of the forester, and to this, the reason of its inclusion here, we shall return in a moment.

The Red Squirrel of Britain (*Sciurus vulgaris leucourus*) differs from all its relatives on the continent of Europe in its smaller size and in the bleaching of its tail, which, since it takes place mainly in early spring, must be regarded as a constitutional peculiarity and not as a mere bleaching due to the brightness of the summer sun.

But, indeed, the present squirrel stock of Scotland can scarcely be reckoned altogether native, for at one period our native squirrels appear to have become practically extinct. This disappearance, which became final in the latter quarter of the eighteenth century, was intimately connected with the destruction of Scottish forests, to which for many years various causes had contributed, the most serious of all being, perhaps, the havoc wrought in the woods by the great iron furnaces of Scotland, where smelting was carried out solely by means of charcoal derived from native timber. Hardly had the extinction of the native squirrels been completed, however, when fresh stocks, imported from the continent, were set free at various places in Scotland, and from these centres the dispersal of the squirrel proceeded with such persistence that, by the end of the nineteenth century, they had recolonised the country from Wigtownshire to the southern border of Caithness, and from the East Coast to western Argyllshire.

Squirrels inhabit woods large and small, finding there abundance of food and shelter. They show a preference for fir-woods, and it is most often in the higher branches of a fir-tree that the sleeping chamber, known as a "nest" or "drey," is built. The nest itself is a grassy structure prepared by the interlacing of grass, moss, leaves and the like, and in such a nest, specially lined with dried grass and her own fur, the female deposits her young. A litter generally includes three or four individuals, but the number may vary from one to six; in Scotland the young are generally found in the nest in April, but we have received several records which indicate the occasional occurrence of a second brood in late summer.

Economic Significance.—The squirrel is a rodent, and a vegetarian by nature. Outside the limits of its "natural" food, squirrels have been known to devour the eggs and sometimes even the young of birds, the most frequent victims being perhaps wood-pigeons and hole-nesting species, such as owls and wood-peckers.

Indeed, its destruction of the eggs of wood-pigeons is, apart from its own beauty and interest, the only item we can reckon to its credit.

Within the limits of its vegetarian diet, the squirrel's choice is almost unbounded, and it is here that it comes into conflict with man. In country gardens it has been known to devour plants and plant-bulbs, and in summer when the fruit is ripe it is fond of paying a visit to orchard trees and strawberry beds. Its more staple food-supply, however, consists of fir-cones, beech-mast, acorns and hazelnuts, and the seeds of other trees such as sycamore and alder, as well as leaf-buds, twigs and the inner bark or bast of trees. The latter depredations have given rise to the enmity between the squirrel and the woodsman. Where squirrels are numerous all kinds of trees suffer to a certain extent from their destruction of young shoots and leaves, or from their habit of tearing through the outer bark, in order to feed upon the juicy bast beneath. There can be no doubt, however, that in Scotland it is most destructive in fir-woods, where not only does it reduce to some extent the possibilities of self-seeding, by devouring the seeds contained in fir-cones, but it may cause incalculable damage by destroying the leading tops, either by gnawing out the young shoot or by stripping or girdling the bark near the summit of the tree, so that the leading shoot withers and the symmetrical development of the tree becomes henceforward impossible. According to Mr W. A. C. Hinton "such crimes chiefly occur in the new woods of replanted areas, and are most often seen in trees of about twenty years growth, younger trees appear to be exempt as do also the older firs of native forests, in which the more abundant cones supply a quantity of food." However it may be with younger trees, I am certain that Scottish foresters would not agree that older firs are free from serious damage by this pest.

The rapidity with which squirrels spread and multiply in suitable areas, and the extensive damage they may cause in their numbers were well illustrated in the woods of Glen Tanar in Aberdeenshire, where, in the first fifteen years after the appearance of squirrels there, 1000 trees valued at £500 were destroyed; on an average about 200 squirrels were killed thereafter in these woods every year.

It is clear that, from the purely economic point of view, the evidence lies heavily against that "merry forester" "the playful squirrel."

Destruction.—Squirrels have few natural enemies, since the pine-marten has almost disappeared from Scottish forests; so that where they are already too numerous, or threaten to become too numerous, man must himself take the remedy in hand. By nature squirrels are rather fearless and inquisitive, so that when disturbed they seldom make a persistent effort to get beyond reach. They thus fall easy victims to the gun, or to less elaborate hand missiles. Excellent results have followed schemes of co-operation throughout a considerable area, for squirrels are great wanderers, and local

efforts at destruction may be rendered ineffective through immigration from less disturbed areas. Co-operation has been found to be most effective when the aid of all and sundry has been enlisted by the offer of a small reward for each squirrel slain. Thus in the Cawdor plantations in Nairnshire, where a reward of a few pence was given for each individual, 14,123 squirrels were presented in the course of sixteen years (1862–1878), for the slaughter of which £213, 13s. 9d. was paid. Still more astounding are the results attained by the Highland Squirrel Club, formed in 1903 to counter the devastation wrought in the woods of Easter Ross, part of Sutherland, and the portion of Inverness-shire north of the Caledonian Canal. Three-quarters of a century ago the squirrel was unknown in this district, yet during fifteen years, up to the end of 1917, 60,450 squirrels had been killed, 1909 providing a record number of 7199 individuals. The price paid for tails by the Club varied from 3d. to 4d.

The most effective season for the killing of squirrels is in early spring, not later than the middle of March, before the breeding season has begun.

The Grey Squirrel.—Although the standing of the Grey Squirrel in Scotland is widely different from that of the Red Squirrel, its potentiality as a pest here is clearly indicated by the course of its history in England. It is a native of North and Central America, and its presence in this country is entirely due to the deliberate setting free of imported specimens, which, finding conditions favourable, have survived and multiplied. From our common squirrel the American Grey Squirrel (*Neosciurus carolinensis*) may be distinguished by its colour, silvery grey on the upper parts and on the under parts almost pure white, as well as by its more clumsy limbs and shorter ears, lacking tufts of hair at the tip.

In England the Grey Squirrel has become established in many areas, notably in Surrey and some of the southern counties—partly owing to wanderings from Richmond Park—in Buckinghamshire—colonised from Woburn—and in the west country about Exeter. In Scotland there are at present few localities where the species has found firm foothold, but the few are sufficient to point a warning finger to danger ahead. A single pair was released at Finnart on Loch Long about 1890, and by 1915 their progeny had spread over an area in the neighbourhood of Loch Lomond measuring some twenty miles long by eight or nine miles broad. From the Scottish Zoological Park at Corstorphine an escaped individual has been found in the policies at Dalmeny; and from Pittencrieff Glen in Dunfermline, where they were set free about 1919, and where they now breed freely, wanderers have been reported from Rosyth and Pitfirn, each several miles away. I think it well to mention these details here, as a warning that, if the indiscriminate setting free of these creatures in Scotland is persisted in, the vitality and adaptability of the squirrels themselves will ensure their speedy addition to the list of serious woodland pests.

In Dunfermline, during the present year, I have seen the stems and branches of trees denuded of great strips of bark by the Grey Squirrels, and large boughs of elm trees withered and dead because of the girdling of the bark at their bases. In Dumbartonshire this alien has been found to be very destructive to the leading shoots of Scots pine—a fatal offence; and in Yorkshire and other parts of England it is known to have destroyed or disfigured scores of deciduous trees, particularly elms and sycamores. And all this in addition to its well-known predilection for the fruits of the garden, and Sir Frederick Treves' allegation that "they eat everything that can be eaten, and destroy twenty times more than they eat."

It is said that the Grey Squirrel, when it becomes established, drives out the native Red Squirrel, but that, if it be so, is but a sorry exchange for the forester.

Rabbits and Hares.—Attention has already been drawn to the ill deeds of these rodents in connection with their destruction of green crops and pasture (this *Journal*, 1922, pp. 358 and 361), but it is necessary again to pillory them in respect of their relations to woods and plantations. They feed upon all sorts of herbage, and thus the leaves, buds and under-bark of trees fall within their normal dietary. The attention which they lavish upon the growing shoots of woody plants is signified by the close-cropped, bee-skep shape of whin-bushes in the neighbourhood of a well-stocked warren.

The amount of damage which rabbits and hares do to trees depends to some extent upon accidents of climate; for it is mainly during a summer period of drought, or during the stress of winter's frosts and snows, when they are driven to feed upon any supply of food available, that they turn to the succulent stores of tree-bark and the like. Fortunately, rabbits and hares, unlike squirrels, are confined to the ground, so that the area of their damage is limited; but this limitation has the disadvantage of concentrating and intensifying the damage. Thus it is that rabbits and hares are more thorough in their destruction of the buds and foliage within their reach, and carry out the girdling of the bark of a tree with greater regularity and perfection. And no matter where a tree trunk may be thoroughly girdled and the sap-conducting bast destroyed, the tree itself is doomed. Nor must it be assumed that the damage caused to trees is confined to the natural reach from the ground of these pests; for in deep snow, when access to fenced plantations is often rendered easy by the presence of snow-drifts, and when the rodents are most severely put to it to find food, they may, supported on a frozen snow-surface, destroy the leading shoots or the bark of trees far beyond their natural compass.

From the foregoing remarks it will be seen that the misdemeanours of rabbits and hares are most serious in young plantations, where the most succulent bark is found and where leading shoots have not grown beyond reach, and in self-propagating

woods, where natural seedlings have little chance of survival in the presence of these voracious nibblers.

The Protection of Trees from Rabbits and Hares.—In the earlier accounts of the rabbit and the hare, reference was made to the methods ordinarily employed in keeping down the numbers of these pests, and the reduction of numbers is one of the only two practicable remedies available in the case of plantations of any extent. The other remedy is the exclusion of the rodents by the erection of rabbit-proof fences. These are constructed of woven-wire netting made of galvanised wire, and having a mesh of about 1½ inches. The height of the fence varies according to the character of the district. Where ground is level and open and there is little danger of snow a two-foot fence may suffice; but where snow lies, netting 3½ feet wide is more often employed, although it is obvious that where drifts occur or deep snow falls, even such netting will offer no barrier to the ingress of rabbits. In order to prevent the burrowing of the rabbits under the fence, five or six inches of the lower edge of the wire should be turned outwards, flat on the ground, and covered with soil or sods.

Where the trees to be protected are few in number, or are of particular value, methods may be adopted which, on a large scale, would be impracticable, owing to the labour or expense involved. Mechanical methods of protection include the erecting of cylinders of wire netting, of 1 inch mesh and about 18 inches high, round the base of each tree. It is advisable to fix the cylinders, by means of wire or wooden supports, at a uniform distance away from the tree trunks, so that the rabbits will be unable to press the wire against the bark and gnaw through the meshes. Cylinders constructed of close-set wooden laths are also used, but they offer undesirable shelter for injurious insects, and on this account should be retained in position only during the winter months, and should be removed in spring when all danger from serious attack is over.

Protection may also be obtained by painting or smearing the bases of trees with substances distasteful to the rodents. But here difficulties arise, for, on the one hand, some distasteful substances, such as tar, may be injurious to young trees, and, on the other hand, many otherwise suitable substances, such as carbolic acid, quassia, and the like, are soon rendered ineffective by the action of the weather. Perhaps the most effective wash, resistant both to rabbits and to rain, is a combination of lime and sufficient copperas (ferrous sulphate or green vitriol) to give the mixture a deep green colour.

In the United States of America the following *poison* wash has been found to be effective. One ounce of *strychnine* (sulphate) is dissolved in 3 quarts of boiling water; ½ lb. of *laundry starch* is dissolved in 1 pint of cold water. Pour the starch into the vessel containing the strychnine and boil the mixture a short time until it is clear, adding 6 ounces of *glycerine* and stirring thoroughly. When the mixture is cool enough apply it to the tree trunks with a paint brush. "The glycerine and starch adhere well and form a

thin coating to the bark. Rabbits attacking the trees will be quickly killed. In the Idaho experiments [in the winter of 1913–14] none of the trees were damaged badly enough to affect their growth, and all the rabbits in the orchard were destroyed . . . *Care should be taken not to endanger domestic animals.*"[1]

In America another method of protection has been tried with success, particularly in orchards, the rabbits being supplied with food during severe weather, on the principle that it is "cheaper to feed than to fight them." In orchards the winter prunings of the trees were left on the ground, and in other cases turnips and vegetables were provided in such quantity during cold weather that the attention of the pests was diverted from the tree-stems to the artificial provender.

Field Vole, Bank Vole and Wood Mouse.—In the preceding article of this series (1923, pp. 25, 28 and 29) it has been stated that each of these pests is responsible, especially in hard winter weather, for a certain and sometimes serious amount of damage to trees, due in the main to their nibbling and girdling the bark of young trees and shoots, and so causing their decay and ultimate death. The lime and starch-glycerine poison-washes described above as effective against rabbits, are equally effective in preventing the attacks of mice; and the method of mechanical protection by means of a cylinder of wire-netting may be adapted against mice by the adoption of a smaller mesh, and by planting the lower edge of the cylinder well into the ground, a precaution which is advisable also in endeavouring to circumvent the wiles of rabbits.

ISLE OF WIGHT DISEASE IN HIVE BEES.

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Symptoms of the Disease.—Writing to the *Irish Bee Journal* in 1906 Mr H. M. Cooper, Secretary to the Hants and Isle of Wight Beekeepers' Association thus described the most destructive of all bee diseases. "In some cases several hundreds of bees are to be seen on the ground near the hive, often crawling rapidly, but quite unable to fly, their abdomens greatly distended and containing a large amount of ropy, yellowish-brown matter. The stocks affected rapidly dwindle, and usually succumb in about a month or six weeks, leaving their stores, and often a quantity of brood. The queen appears to keep healthy and survives to the last." It may be further noted that the "matter" is found to consist mainly of pollen, and that its colour varies according to the flowers from which this pollen was obtained. The pasty mass of pollen grains is contained in the "colon" or lower bowel of the bee, and the insect appears to have lost the power of voiding it. Pressure on the abdomen will often rupture both the colon and the body-wall

[1] In view of the terms of Section 7 of the Protection of Animals (Scotland) Act, 1912, it would appear that such a method would be illegal in Scotland.

of the bee. Bees crawling from Isle of Wight disease will revive if warmed and fed, but the power of flight will not be regained.

Early Virulence of the Disease.—When Cooper wrote in 1906 the disease had been at work on the Island for two years and already 90 per cent. of the stocks had perished. It was equally destructive on the mainland and was particularly severe on beekeepers who kept bees on the most modern (British) principles. In 1910 the disease attacked the model apiary maintained by the British Beekeepers' Association at Swanley, and the whole of the bees perished. At a conference called by this Association in 1911, one member (Mr Jarman) stated that he had lost 120 stocks in six months. Mr W. F. Reid had lost all his stocks in about two weeks. To *Gleanings in Bee Culture* (January 15, 1914) Messrs Smallwood and Herrod, both officials of the B.B.A., contributed articles from which we learn that Oxford lost 80 per cent. of its bees and another unnamed county lost thousands of stocks. When the Ministry of Agriculture took a bee census in 1919 it was found that in all England and Wales there were still only 32,500 stocks of bees. And this by no means represented the lowest point for, as we shall see, recovery was well advanced by 1919. At this date Mr Snelgrove stated that the number of stocks in Somerset was 2000 as compared with 8000 in the period of normal prosperity. For comparative purposes it may be noted that a bee census taken in Scotland in 1920 by the Scottish Beekeepers' Association indicated that the stocks of bees in Aberdeenshire exceeded 9000. During the worst years of the plague Isle of Wight disease was the principal subject of discussion at all meetings of Beekeepers' Associations. Secretaries reported a great falling off in membership because "the members had lost their bees."

Cause of the Disease.—The writer may say at once that in his view the ultimate causes of Isle of Wight disease are to be sought in certain wrong methods of keeping and breeding bees that have been prevalent in Britain for nearly a century. Many proximate causes have been suggested by beekeepers at various times. The importation of foreign bees, displacement of the straw-skep by the wooden hive, the use of comb-foundation, feeding with sugar, poisonous washes applied to fruit bushes, even exhaust-fumes from motor engines, were suggested as being responsible for the trouble. Trained scientists were sent to the Isle of Wight to confer with the beekeepers and to search for the cause of the disease. In 1907 the opinion was formed that the disease was due to *Bacillus pestiformis apis*, in 1912 *Nosema apis* was stated to be the cause, while more recently it has been believed to be a mite discovered at Aberdeen in May 1920.

"**Cures.**"—Bees have recovered after treatment by numerous cures, but they are found to recover quite as often when left untreated. The disease is fluctuating in character, and we have thus perfectly honest testimony to the virtues of a long list of specifics from disinfectants like bacterol, yadil and dioxygen down to flowers of sulphur and aromatic chalk. As regards the dis-

covery of a drug cure the prospects are not very hopeful. Any treatment indeed, whether by drugs or otherwise, that would prolong the life of susceptible stocks of bees would distinctly hinder regeneration in British bees.

Manipulative Treatment.—Mr J. M. Ellis, now of Gretna, but formerly of Ussie Valley, Ross-shire, was a pioneer in methods of control by manipulation. He pointed out that Foul Brood was a disease to which adult bees were not susceptible, and to control it we destroy the brood and regenerate the stock from the adult bees. The brood is not attacked by Isle of Wight disease, so Mr Ellis suggested, quite logically, that we should destroy the adult bees and regenerate the stock from the brood. Messrs Muir, Kirkcowan, tested this on a large scale, but ultimately abandoned the method as being unsuccessful. The development of bee brood in a chicken incubator is a modification of the original Ellis method.

Since the discovery of the bee mite at Aberdeen a new method of manipulative control has had considerable vogue. It has been advocated by Mr Arthur Sturges, by Dr Rennie and others. It proceeds on the known fact that a bee cannot be infested by the mite till it has emerged from the cell. It is assumed that only the older bees can be fully parasitised so as to incapacitate them from work and render them infective by congestion of the mites within the limited area in which alone they can live. The way to control mite disease, says Mr Sturges, is to reduce the average age of bees in the stock. One can make an artificial swarm by leaving the queen in a new hive on the old stance, removing the stock to a new stance. All the flying bees, the bees of about fourteen days old and older, will go back to the old stance. These can be killed with all the mites they may contain, and the stock built up from the young bees that are relatively free from mites. Unfortunately for the complete success of this method, beekeeping depends ultimately on those very older bees so lightly destroyed. The young bees that have never flown are the nurses, the pollen-packers and the comb-builders, but their work is wholly dependent on supplies brought in by the older field bees. The honey-harvest, in particular, is entirely the product of labour by the older foragers. All observant beekeepers are familiar with the pathetic spectacle of the aged forager whose notched and broken wings are just able to take her home with her load of nectar. A beekeeper who keeps killing off his older bees will succeed no better than a dairyman who keeps only calves.

Lessened Prevalence of the Disease.—Nature has succeeded where man has conspicuously failed, It is now about sixteen or eighteen years since Isle of Wight disease became virulent in Britain, and there is a large body of evidence that recovery is well advanced in the regions first attacked. For some years now the writer has systematically collected from the daily and weekly newspapers reports of meetings of beekeepers and other news items bearing on bees and bee culture. These afford very definite evidence of the gradual disappearance of Isle of Wight disease.

Here are some quotations selected from reports in the spring of 1920, referring to conditions in 1919. In Sussex 805 stocks were visited and examined by the experts, and only four cases of Isle of Wight disease were noted. In Kent, Mr Judge "had seen only two or three reports regarding the disease." In Surrey 633 stocks were visited and three cases of Isle of Wight disease observed. Leicester reported that "the outlook was distinctly more hopeful, and the proportion of healthy colonies was far higher than it had been." In Devonshire "Isle of Wight disease was still in the county, but in a greatly lessened degree and in far less virulent form." From Cumberland the report is that "the dreaded Isle of Wight disease is much on the decrease." In Worcestershire "the improvement had been continuous, losses by disease were much less frequent, and stocks had increased rapidly. In 1919 the Suffolk touring expert saw only two cases of Isle of Wight disease and the disease "seemed to be dying out." In Berkshire "the disease was certainly on the wane." Mr M. Atkinson, addressing the Cambridge Beekeepers' in 1920 congratulated them on the report that "Cambs was full of bees." The writer can well believe this report because in July last he met at Cambridge two beekeepers who had 1550 stocks between them. In Hereford "the Isle of Wight disease, so much dreaded by apiarists, was passing away."

In 1920 the Hereford touring expert visited 598 stocks and found four cases of the disease. Glamorgan had a very bad honey harvest in 1920, and it was reported that Isle of Wight disease "is not entirely eradicated." The change in phraseology is very significant. By this time Isle of Wight disease had ceased to be the main topic at meetings of beekeepers in the South and Midlands of England—other aspects of beekeeping having become of more importance. We get an occasional reminder that the trouble has not passed completely out of range. Thus Staffordshire in September 1921 reports that "there does not appear to have been a complete revival after the havoc wrought some time ago by the Isle of Wight disease." At some of the annual meetings held in 1922 Isle of Wight disease was not even mentioned.

In 1918 there was initiated a government restocking scheme by which counties were encouraged by subsidies to produce and distribute nucleus stocks of bees bred from Dutch bees requeened with Italians. Over thirty restocking apiaries were established in England and Wales, and three in Scotland. All these have now been closed down as being no longer required. The note from Cornwall may be taken as a sample: "The Cornwall Beekeepers' Association have made a successful ending of the important business of restocking their hives after the heavy losses sustained owing to the Isle of Wight disease."

It is interesting to follow the improvement in certain counties. In October 1913 the writer was favoured with a letter from Mr H. M. Cooper, the veteran Isle of Wight beekeeper who was the first to describe the disease. He reported that only one Island apiary

remained unaffected. It was a skep apiary and belonged to an old-type beekeeper. Mr Cooper was very despondent. "No matter what I have tried in the way of immune (?) bees, preventive or curative measures, the disease has triumphed over all, and, so far as our present knowledge goes, we are in a hopeless case . . . My method now is to buy bees during the early spring, and work them for one season. They nearly all die during the autumn or early winter. I have now only three healthy lots left from nearly fifty that I worked through the summer." Later it was reported that the last apiary of original Island bees had become extinct, but the Island was never entirely without bees.

In 1919 the Hants and Isle of Wight Beekeepers' Association had again seventy members, and Mr Cooper reported that "all his bees had wintered without loss." Another member stated that his bees had not been troubled by disease since he discontinued feeding them with sugar. At the annual meeting in 1920 the membership had risen to 103. The Government restocking scheme was discussed and criticised unfavourably. One member said: "The disease had now practically abated. Beekeepers as a result of long association with the disease did not now fear it except in the depth of winter. The disease would never be wiped out by the importation of foreign stocks, but by breeding improved home stocks which could resist the disease."

In Somerset the membership of the Association fell from 500 to 50, but it rose again in 1918 to 115 and in 1919 to 257. Snelgrove found only 2000 stocks of bees in Somerset in 1919—when recovery was well advanced—against 8000 before the onset of the plague. At a garden party held in August last the President, Mr T. W. Cowan, stated that "the membership of the Somerset Beekeepers' Association would soon reach pre-war numbers, and the county was practically free from Isle of Wight disease."

We have another proof that Isle of Wight disease is less formidable in the signal success of the Honey Show promoted by the Kent Beekeepers' Association. It was held in the Crystal Palace in September last after the worst season in a quarter of a century, and yet it broke all records for honey shows in Britain. There were 450 exhibits.

It is curious that the favourable impression gathered from reading the ordinary press is not confirmed by perusal of the periodicals devoted to the interests of British beekeeping. We are able, however, to get indirect confirmation by reference to the advertisement columns. The following table is an analysis of bee advertisements appearing in the *British Bee Journal* for corresponding weeks of the last five years:—

Date.	Advertisements of Bees for Sale.	Advertisements of Bees Wanted.
April 18, 1918	7	12
April 17, 1919	10	6
April 15, 1920	43	None.
April 14, 1921	53	None.
April 13, 1922	60	None.

We note with satisfaction that after 1919 it is no longer necessary for beekeepers to advertise for bees, there are plenty offered for sale.

As early as 1914, the experts of the British Beekeepers' Association had noted that the great scourge had abated somewhat. Mr Smallwood, writing in *Gleanings* (January 15, 1914) reports with regard to Oxford and Middlesex:—"I have found very few new cases; in some instances the bees seemed to cure themselves, and unquestionably the colonies compare favourably with the two previous years." In the same issue of *Gleanings*, Mr Herrod (now Mr Herrod-Hempsall), adviser in apiculture to the Ministry of Agriculture, writes: 'In my capacity as junior editor of the *British Bee Journal*, I claim to have the best opportunity of anyone in Great Britain for judging this, and I can assure you it (the Isle of Wight disease) is abating. In some districts it has disappeared altogether."

Lessened Destructiveness of the Disease.—We have seen that in 1906 stocks attacked by the disease died out in a month or six weeks. In 1919 Cooper reported that "the characteristics of the disease had changed somewhat of recent years. When first noticed it was worse in the summer, but now it was seen chiefly in the late autumn and spring." The Rev. W. Murdoch of Culsalmond, speaking at Glassel in August last, said that "Isle of Wight disease used to kill the bees in a week or two. Now they crawled at intervals for a year or more." In 1920 the disease was still in Devon, "but in far less virulent form." In 1921 the report from Worcestershire was that in the previous season the disease "had not given so much trouble as in some years. Not only had there been a smaller proportion of attacks, but what there had been seemed to have been much less fatal, many of the stocks now recovering."

The writer's personal experience over a wide area in the North of Scotland supports the view that the power of resistance is growing among bees that have been in contact with the disease for years. At one time thousands of bees would crawl out of a stock on a fine day, and litter the ground in a fan-shaped space extending several yards in front of the hive, and this too in the finest weather. Now these symptoms appear only when conditions are unfavourable to bee life. The disease displays all its original virulence when it reaches a new district, but in general the very susceptible bees—that would crawl under the most favourable conditions—are already extinct.

Probable Explanation of Lessened Destructiveness.—The improvement in the situation is beyond dispute, and we must try to account for it. In 1918 it was claimed in a "publicity paragraph" issued to the press of the country that "the decreasing virulence . . . is believed to be due in great measure to the supply of medicated candy by the Government during the past few seasons." But if the mite theory of the disease be accepted it is difficult to see how medicated food can affect a parasite not situated

in the digestive system. The importation of foreign bees must also be discounted as a factor in the improvement, for Dr Rennie has found that "Egyptian, Dutch, Punic and Italian bees can be readily infected, and in these *Tarsonemus* multiplies with disastrous results, as in British bees."

Much more probably we have here one more illustration of nature's way with an infectious disease. Bees differ in their power of resisting this disease. Some are very susceptible and die under conditions very favourable to bee life. Others are more resistant and survive under ordinary conditions. The susceptible bees tend to die out, but this only makes more room for the multiplication of the more resistant. The parasite may still infest the bee, but host and parasite become so adjusted to each other that the host is not affected to any appreciable extent.

It has been held that this reasoning is not applicable to such a form of parasitism as has been discovered in the bee. Acarine Disease is not an "infection" but an "infestation," and a bee can never be immune to—fortified against—a mite. But the resources of nature are not so limited as all that. Writing of grouse in *The Deeside Field*, Professor J. Arthur Thomson says:—"There seems to be no specific 'grouse disease,' but when the birds live too sheltered a life and constitutions below par are tolerated, then the parasites of the grouse—normally kept within bounds—get the upper hand, and are fatal to their hosts."

There is evidence that some bee strains are highly resistant to mite infection. Rennie, White and Harvey instance a stock in which the mite infection increased in four and a half months from 0 per cent. to 92 per cent., and yet the bees displayed no disease symptoms whatever. From the *Bee World* for October 1921, we learn the following interesting facts:—On January 9th, Dr Rennie had certified that the bees from a certain stock had *Tarsonemus woodi*. On the 23rd of May that stock swarmed, and this swarm swarmed on June 28th. The beekeeper had taken off 150 sections, and had three very strong stocks when he wrote in September.

The Influence of the Queen.—As noted already it is a curious fact that in a stock dying of Isle of Wight disease the queen survives to the last. Such queens introduced to new stocks are readily accepted and breed normally. The stock so treated does not, in the writer's experience, immediately display any symptoms of Isle of Wight disease. Numerous experiments have been made in recent years, and it was invariably found that "crawling" was developed just as soon as the bees produced by the Isle of Wight queen were subjected to strain by having to bear the burden of the work outside the hive. Rennie and Harvey arrived at a quite different conclusion. After several experiments they found that "such queens do not produce bees that are specially susceptible."

The Eddowes Method of Disease Control.—Writing to *Gleanings in Bee Culture* (December 1, 1913), Mr C. N. Eddowes of Jamaica describes how he dealt with "paralysis" in the apiary

of the Government Farm School. "In 1905 I bought forty colonies of bees. When the season came when bees are attacked with paralysis, the apiary was strewn with dead and dying bees, so that it was impossible to take a step without treading on bees. I noticed, when examining the hives, that there were two colonies that did not show signs of paralysis. These two queens I picked to breed from. The next year the improvement was marked. I continued to pick my queens in this way until I rarely have more than 1 per cent. of my colonies attacked by paralysis." By selection in the female line Mr Eddowes succeeded in raising the percentage of resistance from 5 per cent. to 99 per cent. in eight years. He still had the disease in 1913, just as in 1923 some beekeepers in even the south of England will have a percentage of Isle of Wight trouble. But when the percentage is reduced to a single figure beekeeping has become a pleasure once more.

In a second contribution to *Gleanings* (April 1, 1916) Mr Eddowes reiterates his belief that "the only cure for bee paralysis is to select and breed immune stock." In giving the symptoms of "paralysis" he mentions that the abdomens of the bees are greatly distended by accumulated fæces. The bees crawl out of the hives and fall to the ground. In bad cases they cluster in bunches of from ten to thirty.

Mr F. R. Beuhne, apiarist to the Government of Victoria, Australia, writing to *Gleanings* (April 15, 1916) states that "paralysis can be produced in any colony by the introduction of the queen from an infected colony." He had at Burnley an apiary that was free from paralysis. To several stocks in this apiary he introduced queens from colonies affected with paralysis, with the result that symptoms of paralysis appeared in from five to six weeks later. When these queens were replaced by queens of a resistant strain all signs of paralysis disappeared in a little over two months.

How Resistant Bees Emerge.—We have seen that the Isle of Wight did not lose all its bees at once, and there were still some of the original bees in 1913. These were probably resistant, and the Island might have been restocked from their descendants. But these resistant survivors were swamped through inter-breeding with bees constantly being imported, and selected by preference from districts not yet reached by disease. We note also that a proportion of the Somerset bees survived, and in 1919 there were still 32,500 stocks of bees in England and Wales. It is for those who believe that all bees are equally susceptible to tell us why there were any survivors.

Practical beekeepers have noticed for years that a clean sweep of an apiary is becoming more exceptional: usually one or more stocks survive. This was noted in Stornoway as early as 1912. At Stoneywood Station in 1919, twenty-nine stocks died in an apiary of thirty stocks. The surviving stock duly robbed the dying colonies but remained healthy. Mr Moir has still at Inverurie some perfectly healthy stocks descended from this

survivor. In 1921 Isle of Wight disease reached Rogart in Sutherland, and the usual report was current that all the bees in Rogart were dead. The teacher reports that one of his stocks never showed any symptoms. Were it necessary these examples could be multiplied to almost any extent.

Practical Measures.—It is obvious that measures of segregation, legislative control, compulsory disinfection, etc., which have more or less success when applied to man and the higher animals, are quite inapplicable to bees, because their movements are so entirely beyond control. Even though a perfect drug cure could be discovered its usefulness would be very limited owing to the short life—a few months at most—of the worker bee. Still the case is not hopeless. There are many diseases even in man which are quite beyond his control, and yet the species is in no danger. In such a case there is naturally developed a race or strain which is resistant to or tolerant of the disease. This is what is happening with the bees, and it is for beekeepers to help on this natural process.

Eddowes and Beuhne have shown the way. We must replace susceptible bees by resistant bees, and this may be effected by requeening with queens from a resistant strain. Requeening must be done sufficiently early in the season to enable the new queen to produce enough bees for wintering. When buying fresh stock we must carefully avoid bees from the few secluded glens that the disease has not yet reached. Such bees have been "sheltered" from the disease, and probably a high percentage of them will prove non-resistant. We should rather buy bees bred from surviving stocks in districts already swept by the disease. The regeneration of the bees in Britain has made unexpectedly rapid progress, in spite of difficulties connected with the wandering of the drones, and the ease with which bees and queens can be conveyed long distances. Even without the co-operation of the beekeeper, biological law will in due course relegate Isle of Wight disease to a position of little importance. But why should we stand by?

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WHEAT BULB DISEASE.

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THIS disease has long been known throughout Britain and on the Continent. Of recent years in Scotland it has done considerable damage in the Lothians, Forfarshire and Fifeshire, and in other areas where there is a short rotation of crops, and where much wheat following potatoes is grown. The young wheat plants during March and April wither and die off, being destroyed by the grubs of a species of fly called Lepto hylemyia coarctata (*Fall.*), in such numbers that occasionally the crop is practically ruined, but more often is thinned and made patchy to such an extent that the profit margin is wiped off.

At the request of the Board of Agriculture for Scotland I undertook an investigation in order to clear up, if possible, certain points that were still doubtful regarding the life history and habits of the fly, keeping specially in mind the chance of discovering from these some workable methods of prevention or remedy. The following is a brief summary of the results of this investigation, beginning with life history and habits :—

Life History.—The flies become fully grown in July and lay their eggs towards the end of that month and in early autumn. The crucial point was discovered that the places chosen for laying the eggs are practically always bare loose soil surfaces, preferably among early or second early potatoes, more sparingly among late potatoes or fallow, still more sparingly as a rule among other root crops, and practically never among wheat itself or other cereal crops or beans or in pasture. During the winter months the eggs remain in the soil but the grubs are slowly developing within them, and they hatch out in early spring, chiefly in February. The newly-hatched grubs seek out and enter young wheat plants on which they feed till they are fully grown in the beginning of May. The grubs then leave the wheat plants, bury themselves about an inch deep in the soil close at hand and become motionless pupæ with a firm outer covering. From the pupæ the flies emerge in late June or early July, and they gradually leave the wheat fields and lay their eggs in early autumn in the localities defined above. The number of eggs laid is about fifty for each female. The flies die off completely during later autumn.

The eggs may be detected in and recovered from the soil, and their numbers in any given sample of soil counted by special methods. Each egg is a creamy-white, longish oval about $\frac{1}{20}$ inch in length, $\frac{1}{60}$ inch in breadth, rather flat at one end, bluntly pointed at the other and showing very numerous longitudinal ridges and furrows on the surface, which run sparingly into one another. The grubs when they hatch out are about $\frac{1}{18}$ inch long and have two pairs of sharp curved teeth which enable them to bore into the young wheat plants. They moult twice at least, and at the first

moult the number of teeth is reduced to one pair. When fully grown the grubs measure rather less than half an inch in length. They look like whitish "maggots," pointed at the front end, blunt at the posterior end, the former showing two dark, curved, notched teeth, the latter showing a very characteristic arrangement of spines. These spines are nine in number, the largest being a pair of double-pronged spines at the middle of the ventral margin. With a little care any one can dissect out the grubs from infected plants. It is exceptional for more than one grub to be found in a single plant. The pupæ are of the usual barrel shape, very faintly ringed, almost smooth between the rings, reddish brown in colour, and showing remains of the characteristic spines at their posterior end. The flies are grey or grey tinged with saffron, rather more slender than the house fly, with one pair of wings which show no spots, and with the upper parts (*i.e.*, down to and including most of the tibia) of all three pairs of legs yellowish in colour. The flies themselves are perfectly harmless. They feed on plant juices and on pollen, and as above indicated they mature in three or four weeks after they have hatched out from the pupæ.

Infected Areas and Methods of Attack.—Investigation of an infected district showed that, within it, the areas in which the wheat bulb grub is most abundant are those in which most wheat following potatoes, especially early potatoes, is grown. In such areas the worst infected fields in any one year are those which, in the previous year, were neighboured by infected wheat fields. The parts of a field worst damaged are usually those in which the shaws of the previous year's potatoes left much bare ground between them or withered early or were early dug up. Even in badly infected areas wheat which follows wheat, or follows beans or any other cereal or rye-grass or pasture does not suffer. The fly does not generally migrate far from the wheat fields in which it was reared in order to lay its eggs. As regards the amount of infection it is estimated that when the soil during November contains over 500,000 eggs per acre the infection must be considered serious and the damage to the future wheat crop will be well marked. Similarly in the spring, fields of young wheat which have more than 300,000 infected stalks per acre will show signs in summer of damage by the disease. In such areas it was noted that, during July, 25 per cent. to 50 per cent. of the flies obtained by netting are the wheat bulb fly.

It was found experimentally that the newly hatched larvæ never attack the wheat seeds, but bore into the young plants from the soil at or close above the bulb of the young shoot. Reaching its centre they gradually work upwards in a spiral for one to three inches. An infected wheat plant soon shows discoloration of the bulb and withering of the central blade, the outer blades at first remaining apparently healthy. In very young and in poorly growing wheat, the whole plant then withers and dies off; the larva leaves it and finds its way to a second plant which becomes affected in the same manner. A third and even a fourth plant

may thus suffer from a single larva. However, the number of plants destroyed by any one larva depends on the size and the vigour of the individual plants. If an infected plant is strong enough to grow lateral buds the larva, after destroying the central shoot, may complete its growth in these, and the plant may even save itself by sending out good additional lateral buds, *i.e.*, by "tillering out." It is worthy of note that lateral buds arise more quickly in plants springing from seed with a moderately shallow covering than in those from deeply buried seed. It is also common knowledge that growth of lateral buds is stimulated by various methods of treatment in spring, *i.e.*, light harrowing and rolling and the application of a suitable manure.

It was found extremely difficult to destroy the eggs in the soil or the larvæ in the plants except by methods so drastic that they would destroy the wheat plants as well. Thus, the eggs in the interstices of the soil remain undamaged by heavy roller pressure and only a small proportion of the larvæ in stalks are crushed by similar pressure. Both eggs and larvæ withstand freezing except when it is extreme. They withstand also in a remarkable degree the action of many different kinds of poisons and chemical agents, *e.g.*, strong brine, copper sulphate, picric acid and clensol. A field experiment with soil fumigant was tried, but failed to give satisfactory results. The grubs are unable at any stage to feed on the soil itself, though they can burrow through the soil in search of their host plants, and they seem to travel most readily through the looser soil of the plough furrows, but such migrations are only for short distances, probably not more than a few feet in the case of any one grub.

Just after hatching they can survive for only five or six days unless they get the chance of feeding on young wheat or other susceptible plants. Later on, after they are half grown they can live without food for about fifteen days. It is important to note also that grubs hatched out from eggs which were buried down to depths of six inches under the seeds of young wheat plants found no difficulty in coming up and infecting these plants. From this and from field experiments carried out by Mr Ogilvie, Ardestie Mains, Monifieth, it is judged that deep ploughing offers no security as a method of prevention.

An important point to determine was whether the wheat bulb grub can infect and complete its life history in any other plants besides wheat and in particular to discover what is the natural wild host and reservoir of the pest. A great many experiments were accordingly undertaken to determine these points and it was discovered that newly hatched grubs can infect and can complete their life history in barley, rye and couch grass (*Agropyrum repens*). And further it was found that larvæ could pass from any one of these or from wheat into any other of the four. On the other hand, oats, ordinary field and sand grasses, potatoes, turnips, cabbage, mustard, etc., did not suffer from the attacks of the grub. It is probable that couch grass, which is a kind of wild wheat, is the

natural wild host of the fly, and that originally the wheat-bulb fly was really a couch-grass fly and that in course of time, with a modification of its instincts as regards egg laying, it became a regular parasite of cultivated wheat as well. Even yet a newly hatched grub can complete its growth in good succulent couch grass rather more quickly than it can in wheat, Fortunately couch grass is not so abundant as a rule in well-cultivated ground that the grubs can be reared in it in sufficient numbers to maintain a really damaging stock of the flies. Again barley and rye being sown as a rule in spring are not open to the attacks of the grub since the young plants are not ready for infection till well after the time when the newly hatched grubs will have died off for lack of suitable food. It is of interest to note that, although couch grass is apparently the natural wild host of the fly, the eggs of the fly are laid in abundance on ground entirely free from this grass.

Preventive or Remedial Measures.—Once the young wheat in a field is infected, it seems practically impossible to kill off the grubs. The most promising treatment is to do everything possible, by suitable manuring, light harrowing and rolling, etc., to stimulate the growth and tillering out of the surviving plants or shoots. The power of recovery in wheat under favourable circumstances is amazing, and many times it has surprised me to find in summer a crop only some 20 per cent. below normal in a field which during spring seemed to promise less than a 50 per cent. average.

But the most thorough action to take throughout infected areas would be to avoid sowing *winter* wheat or *winter* barley or *winter* rye after potatoes or other root crop or fallow. Since the eggs are laid only on such ground and since they all hatch out during early spring it is evident that if this were done for a single year the numbers of the fly would be tremendously reduced, and probably it would cease to be a menace for many years to come, during which the customary rotation could be followed. Were it not for couch grass, it is judged that this measure would practically extirpate the fly but even in the case of couch grass the possibilities as regards numbers are limited and it would take years for the survivors to be so numerous as to cause danger. Short of this drastic procedure the following may be recommended in infected areas.

1. Wheat should not be sown after *early* potatoes or sown there not earlier than the middle of February.
2. As far as possible try to arrange that potato fields shall not be close neighbours to wheat fields in the same year, if the potatoes are to be followed by wheat.
3. Take all means possible to get rid of couch grass.
4. Very deep burial of the seed at sowing time should be avoided since shallow-rooted wheat plants tiller out earlier than more deeply rooted ones. There is, however, the danger in particular years that wheat rooted quite on the surface may be thrown out by alternating frosts and thaws during spring.

5. Should a wheat field be so badly damaged that it has to be resown it would be better to plough down rather than grub or harrow, and to re-sow with oats rather than with barley, since the grubs already present in the wheat might migrate into the young barley when it grew up, while oats are immune.
6. If a soil fumigant is tried to kill the eggs, the trial should be made before the wheat is sown and as soon as possible after the middle of September because the grubs which are developing within the eggs gradually acquire a resistant covering or cuticle which helps to protect them from the action of poisons.
7. Cropping of the young wheat during spring by sheep has been suggested, and in a particular case appeared to give good results, but further experiments will have to be made before this method can be definitely recommended. It would have the advantage that a proportion of the grubs would be nibbled up with the plants and thus destroyed.
8. Make sure that a sufficiency of seed is sown, so that even if a fair number of young plants is killed off by the grubs, enough may still remain to provide a crop.

Of course, as is well known, there may be other insect enemies of wheat in the early spring months, besides the wheat bulb grub, *e.g.*, the familiar wire-worm. But from the notes given above, farmers should have little difficulty in distinguishing damage due to the wheat bulb grub; and the writer would be glad to receive reports, accompanied if possible by specimens, from localities in which its presence is ascertained or suspected.

THE SHEEP HOOK-WORM IN SCOTLAND.

THOMAS W. M. CAMERON, M.A., B.Sc., M.R.C.V.S.

DURING the year 1922 a systematic examination has been made of the parasites of the intestinal tract of sheep at Slateford Abattoir, Edinburgh, and at other abattoirs in various parts of Scotland which have been visited for this purpose.

Hitherto the sheep hook-worm (*Bunostomum trigonocephalum*) has been regarded as of rare occurrence in this country. These investigations have shown not only that it is not rare but that, on the contrary, it is one of the commonest parasitic worms in sheep. It is universally distributed throughout the country, and was found during the past year in every flock which was examined. It was never found in lambs, even though shearlings in the same flock were infected. The systematic collection at Slateford has shown also that at no season of the year is the sheep entirely free from this parasite.

The sheep hook-worm is a round worm closely related to the hook-worms of man and of dogs. The sexes are separate. The

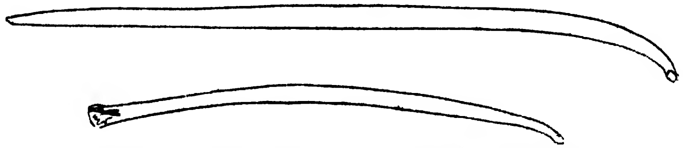


FIG. 1.—Female of *Bunostomum trigonocephalum*, magnified four times.
FIG. 2.—Male of same species, magnified four times.

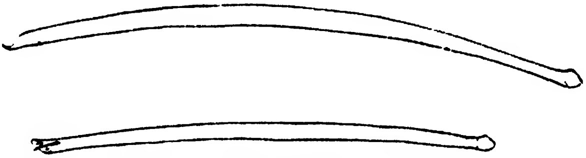


FIG. 3.—Female of *Chabertia ovina*, magnified four times.
FIG. 4.—Male of same species, magnified four times.

female is about an inch long, while the male is about three-quarters of an inch long. Both are about as thick as a small needle. As a rule the parasites are white and glistening in appearance, but specimens which are gorged with blood are reddish in colour. When examined with the naked eye the female appears to be pointed at both ends. When looked at under a hand lens, however, it will be noticed that the head end (which is bent at an angle to the body) is really cup-shaped (Fig. 1). This is shown enlarged in Figure 6. This cup (or "buccal capsule" as it is called) is armed with teeth, and is the means by which the worm attaches itself to the wall of the intestine. The male worm (Fig. 2), as seen under the magnifying glass, resembles the female, so far as the head is concerned, but the posterior end, instead of being pointed as in the female, is expanded into a "bursa" somewhat resembling a collapsed umbrella (Fig. 5). The cup-shaped head of these worms is sufficient to distinguish them from all other worms found in the small intestine of the sheep. Another worm (*Chabertia ovina*) which occurs in the large intestine has a somewhat similar appearance, but in this worm, however, the cup is large, broader than the body and easily seen with the naked eye (Figs. 3 and 4). In *Bunostomum* the cup is narrower than the body, and is not evident to the naked eye. *Chabertia* is generally considered to be comparatively harmless, and is not a "blood sucker."

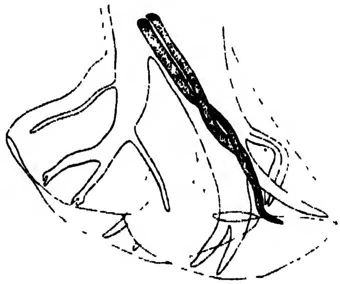


FIG. 5.—Posterior end of male of *Bunostomum*, showing spicules (spotted) and "bursa." Highly magnified.

The life history of the hook-worm in sheep is still unknown. Dr A. J. Hesse has recently shown that the egg, which passes to the exterior in the sheeps' droppings, hatches and a larva appears. After moulting, this larva becomes ensheathed and is extremely resistant to drying. It may be moistened and allowed to dry up time and again. Each time moisture revives it, and each time drying causes it to take on its former resistant state. It is still uncertain how long this stage can last, but larvæ hatched on the 10th of June were still able to revive on the 30th of October, and would probably survive much longer. Dr Hesse's results seem to indicate that infection is caused by the sheep eating encysted larvæ with the grass. This part of the life-cycle has, however, not been worked out.

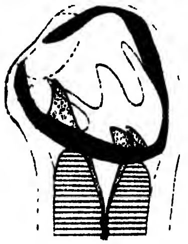


FIG. 6.—Head end of *Bunostomum* from side, showing rigid buccal capsule (black), teeth (spotted) and beginning of digestive system (shaded). Highly magnified.

This worm is closely related to the hook-worms of man and of the dog, which may produce very serious symptoms in their hosts. Probably, similar symptoms are caused by *Bunostomum* in the sheep, but these have not been investigated.

The sheep hook-worm is a blood-sucker; there is, consequently, in heavily-infected sheep, a loss of blood with accompanying poorness of condition and lethargy. This will no doubt be progressive, and the animals will sink into a coma and die. At least several members of the flock may be expected to show the symptoms. Fever will be absent. Watery swellings may be present in the lower parts of the body—under the jaw and along the abdomen. Acute diarrhœa may be present. The lesions caused by the worm in the intestine may allow bacteria to enter the intestinal wall and so give rise to other troubles. The symptoms will probably be somewhat similar to those exhibited in stomach-worm disease, and in order to make diagnosis certain, a post-mortem examination of the intestine is very desirable. It is possible that the worm secretes a special poison, but this is not definitely known.

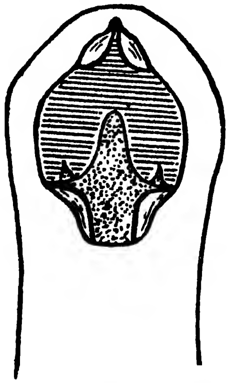


FIG. 7.—View of head from below, showing mouth opening, with cutting plates and teeth (spotted). Magnified.

Treatment is as yet uncertain. Various substances have been tried, but as all are dangerous in the hands of an inexperienced user, the advice of a veterinary surgeon should be taken as to the measures desirable. Even more important than treatment is prevention. Until the full life-history is known, methods of prevention cannot be fully devised, but the following suggestions may be given. Pasture rotation and the ploughing up of badly infected fields. Marshy

ground is probably more dangerous than dry sandy soil. If a flock is badly infected, new, non-infected animals should be kept in clean fields away from the infected stock. *Bunostomum trigonocephalum* has been recorded only from sheep and goats, and if it can be shown that cattle and other stock are immune to it, infected pastures could be utilised for such stock.

Much more information about the pathology of this worm is urgently required, and can be supplied only by the agriculturist on the spot. If any farmer whose sheep show symptoms somewhat similar to those detailed above would send to the writer the intestine of one or two of the sheep, he would thereby assist in helping to solve many problems. The intestine should be accompanied by particulars as to symptoms, duration of illness and number of sheep affected, and should be posted (preferably in a box), addressed :—Department of Helminthology, School of Tropical Medicine, Endsleigh Gardens, London, N.W. 1.

RECENT GERMAN LITERATURE ON THE POTATO.

BEFORE the war Germany surpassed all other countries in potato production. Russia, it is true, had the largest acreage under potatoes, but the yield per acre there was considerably lower than in Germany. According to one authority (1) the total yield of the world as averaged between the years 1909 and 1913 was 147,187,000 metric tons. Assuming that this figure is approximately accurate under post-war conditions, then Germany with a production in 1921 of 45,775,000 metric tons may be considered as producing one third of the world's crop of potatoes. Germany has always been noted for scientific research work and it is therefore not surprising to find that such an important crop as potatoes has received a great deal of attention from scientists and that a considerable volume of valuable information on potato culture has been collected. This article is an attempt to set out some of the more important of the German observations or experiences. It is, of course, understood that only that portion of German literature which is available in this country has been surveyed, and that a certain caution must be exercised in accepting, as generally applicable, phenomena which may be peculiar to German conditions of soil and climate. Subject to these reservations, however, the following notes may be found interesting and suggestive of new ideas to potato growers and raisers in this country.

Breeding.—A question which has always been of interest is whether or not it is possible to obtain from self-fertilised seed, plants which will surpass their parents in productive power. Many of our older varieties, *e.g.*, Victoria, Magnum Bonum and Champion, are the results of self-fertilisation, and there is no doubt that a considerable number of breeders are working with selfed seed.

Wacker (2) states that an improvement of the potato through selfing is not to be expected. He found that sometimes for the first year or two such seedlings showed luxuriant growth and gave rise to great expectations. However, after three to four years the yield began to decline until ultimately it was less than the mother plant. Baur (3) attributes this lack of vitality to degeneration caused by inbreeding. As insufficient details are given with regard to the above experiment, the result must be accepted with reserve.

The significance of disease resistance is fully realised in Germany where attempts have been made to secure varieties immune not only from wart disease, but also from scab (*actinomyces*). At least one variety is immune from scab, viz., Richter's Jubel (4) (5); Deodara, Helios and Hindenburg, each of which has Jubel as one parent, are scab resistant.

One of the limiting factors in breeding is the difficulty of persuading some of our better varieties, *e.g.*, Arran Chief, Great Scot and King Edward to flower and set fruit. According to Bornemann (1) (6) this difficulty can be overcome by the expedient of increasing the amount of carbon dioxide in the atmosphere. Details are given of one experiment. Two plants of the same variety were treated in all respects similarly except that plant "A" was grown with an excess of carbon dioxide in the atmosphere, whereas "B" was grown under normal conditions. "A" bloomed earlier, for a longer period and more profusely than "B." At the beginning of June 220 flowers were counted on "A" against 134 on "B," while the former set twice as many berries as the latter. The explanation given is that, where the gaseous supply of food above ground is greater than the underground mineral supply through the roots, the plants are forced to store up reserves (starch) or to form organs, *e.g.*, flowers, which will consume the carbon more especially. Snell (7) suggests the grafting of potato foliage on to tomato stocks as a means of producing a more prolific formation of flowers.

Seed. *Cutting of Seed.*—A fair number of experiments have been conducted in Germany to test the value and best method of cutting. According to Appel (9), Paulsen (8) and others (7), cutting of seed is an emergency measure; all experiments show a decrease in yield through the use of cut seed. In many cases this can be accounted for by the number of blanks which occur when this system has been adopted. Appel attributes the blanking to the greater accessibility of cut seed to disease organisms, a surmise which has some foundation, as the larger the cut surface exposed the greater the frequency of blanks. Paulsen (8) found that where freshly cut seed was planted there was a greater number of blanks than occurred when the cut seed was allowed to dry before planting. According to him, when the potatoes are to be planted on open healthy ground, especially sandy or peaty soils, the period between cutting and planting may be short; on the other hand, if the ground is heavy and unhealthy, the cut tubers should be allowed sufficient time to dry thoroughly before being planted.

The method of cutting is by no means to be disregarded. Potatoes can be cut longitudinally into two or more equal parts, each of which may be planted, or the tubers may be cut at right angles to the main axis in such a manner that the rose-end is separated from the heel-end. With this latter method the rose-end alone is planted, the remainder being generally used for other purposes. In practically every test the greatest yields were obtained from seed in the following order:—1. Whole seed; 2. Rose-end; 3. Longitudinal Sections; and 4. Heel-end.

It would appear from all the data given that cutting should only be carried out when absolutely essential, with suitable varieties, and when the conditions are favourable for quick growth, *e.g.*, on warm open soils. The above is quite in harmony with experience in this country.

The Importance of Large Seed during Drought.—Remy (1) assigns to the seed the important *rôle* of water collector; after each rainfall the partially emptied mother tuber is said to absorb water which it gives up to the plant when drought sets in. For this reason large seeds produce plants which are less severely affected by prolonged dry periods than plants originating from small seed.

Growth.—Snell (1) states that the eyes and the eye tissues of the seed are not the only portions which can give rise to sprouts. He found that when a tuber was cut longitudinally, all the eye tissues removed and the two halves buried in moist sand, in four to six weeks a callus commenced to grow, which either encircled the vascular bundles or covered that portion enclosed by the vascular ring. After a long time, towards September or October, this callus sent out shoots which, given suitable weather conditions, developed into new plants. Again, if the tuber were cut into two parts at right angles to the main axis, the callus was formed only on that portion containing the rose-end; but if the tuber were cut into three portions transversely, the middle portion built a callus only on that surface which was nearest the heel-end.

The Influence of Soil on Seed.—F. J. Chittenden, in a paper delivered at the International Potato Conference in London, 1921, stated that of seed tubers grown at Wisley those from a peat bottom soil give better yields than those grown on a sandy loam a few yards away. This seems to verify an impression which has been prevalent for some time, but which has never been tested by definite and conclusive experiments in this country.

Details of German experiments on the point are given in the works of the Institute for Potato Research (8) (9). It would appear in general that the most suitable soils for the production of seed, other things being equal, are in order of importance (*a*) peaty, (*b*) sandy, and (*c*) sandy loam soils. Loamy soils do not seem so favourable. Appel (10) states that within a small area seed from sandy and peaty soils is to be preferred to that from heavier land. An explanation of this phenomenon is not given, but it is suggested elsewhere that a high soil content of mineral salts is not beneficial to seed (11). In this connection it is of

interest to note that seed from peaty land is very highly regarded by farmers in this country, but experience shows that the maturity of plants derived from such seed is invariably late.

Influence of Manuring on the Quality of Seed.—Experiments on the above subject are reported in several works (8) (9) (11). According to one experiment the best seed was derived from plots which received complete artificials (nitrogen, potash and phosphate). Partial manuring did not give such good seed. In this experiment the addition of farmyard manure to the artificials seemed to act adversely on the seed. Another experiment demonstrated the advantage of seed derived from a weakly manured plot over that originating in a strongly manured plot. Of all the experiments, however, the most interesting are those of Hiltner and Lang (11) on the influence of over-manuring on the yield and running-out of the potato.

As a result of previous observation, the above writers came to the conclusion that the conditions of nutrition had great influence on the falling off or degeneration of stocks of the potato. By degeneration is understood a decrease in yielding capacity, correlated with such manifestations as poor growth, dwarfing, curling of leaves, blanking, poor reaction to manures, etc. Experiments were laid out to test the effects of over-manuring on the seed. It is to be noted, however, that all tests were carried out with artificials alone, and with the late maturing variety, Wohltmann. The writers, however, consider it justifiable to assume that the results would hold good with all varieties, especially the sensitive Earlies. During the years 1918, 1919 and 1920 three principal experiments were conducted. Plots were laid out at Nederling in the following order :—

1. Unmanured.
2. Complete manure (in simple, triple and quadruple doses).
3. One-sided nitrogenous manuring (in simple, triple and quadruple doses).
4. One-sided potassic manuring (in simple, triple and quadruple doses).
5. One-sided phosphatic manuring (in simple, triple, and quadruple doses).

In 1918 seed from origin A was grown at the station, and the results noted. In 1919 the seed from the 1918 plots was grown again with the same manuring along with fresh seed of origin A. In 1920 a fresh lot of seed from origin A was grown on the plots along with the produce from the 1918 and 1919 stocks. Apart from these principal experiments, however, parallel tests were made to determine the effect of the above manuring when the seed was planted on normal and uniformly manured ground.

The results are highly interesting and instructive.

It was found that in every case fresh seed from A reacted well towards the manures; greatly increased yields and profits accrued to increasing quantities of full and nitrogenous manuring; potash and phosphatic manures were less effective, probably owing

to the nature of the ground. However, with regard to the second and third crops at Nederling the behaviour of the seed was quite different; the yields on the overmanured plots were small and decreased with the larger doses. These differences were most pronounced in the third crop, although it is to be noted that the phosphatic manures in this crop tended to retard degeneration. The capacity to react well towards manures seemed to be lost through over-manuring with artificials.

When, in the parallel experiments seed was planted in normal and uniformly manured soil, it was found that degeneration was hastened by the previous overdosing with full and one-sided artificial manures. One experiment gave the highest yield from seed derived from the unmanured plot; while another showed slight *increases* with seed from simple full manuring, simple and triple nitrogenous manuring, triple phosphatic and simple and triple potassic manuring; while *decreases* were recorded in triple and quadruple full manuring and quadruple nitrogenous, potassic and phosphatic manuring.

In general the experiments showed that seed coming from soil which has been manured with artificials in a greater measure than usual behaves itself differently according to the nature of the ground on which it is grown, but that overdosing with full or one-sided artificial manures to all appearances adversely affects the suitability of the produce for seed.

The writers advise the use of only moderate quantities of artificials in conjunction with farmyard manure which latter lessens the degenerating influences of the minerals. A full explanation of the above phenomena is not given but it is not suggested that the degeneration is permanent. The adverse effect of farmyard manure reported in the first experiment does not seem in harmony with the outcome of the other experiments. As, however, details of previous manuring are not given, this result need not be considered conclusive.

Immature Seed.—A highly instructive paper on the above subject is given by Professor Dr H. C. Müller and Dr E. Molz (17). The experiments quoted by the above authors show evidence of having been conducted with extreme care and conscientious regard for detail. After briefly surveying the history of the question, the writers proceed to describe their experimental methods.

The varieties used in the trials were Reingold, Weisze Nieren, Fürstenkrone, Industrie and Beseler. Previous experiments had shown that where seed tubers of similar sizes were compared, those lifted prematurely invariably gave greater yields than did those which were fully mature. In the experiments under consideration the effect of cutting down the shaws while these were still green was determined. Care was taken to eliminate the possibility of greater yields being accounted for by the unconscious selection of seed from vigorous plants.

The results may be summarised thus:—Seed potatoes, which have been lifted while the plants were still green or which

have originated from plants the shaws of which have been cut while green, give in the subsequent year a regular, luxuriant growth and greater yields than seed which has been allowed to mature fully.

Trials conducted to determine the most suitable date for cutting the shaws, demonstrated the fact that the cutting may be carried out too early and with detrimental results. Decreases in yields were also recorded when seed was taken from a very late planted crop—a phenomenon to be correlated with too early cutting.

The final explanation of the greater productivity of immature seed as compared with ripe seed is still in doubt. The writers suggest that the cutting of the shaws has much the same effect as growing plants in the shade. Experiments are cited to show that seed from plants grown in the shade produces greater crops than does seed from plants grown in full sunshine. The opinion is mooted that under such conditions "shade-eyes" are formed on the tubers, that material, especially ferments, remain active in such tubers after they are lifted and cause an early growth of vigorous and high-yielding plants. Of course, the possibility of an inhibiting factor developing in mature seed is not to be lost sight of.

With regard to these experiments it should be stated that in this country it is a generally accepted fact that unripe seed is preferable to mature seed.

Manures. INFLUENCE OF MANURES ON THE COMPOSITION OF THE POTATO.—The factors which influence the composition of the potato tuber are (*a*) the nature of the ground; (*b*) the climatic conditions; (*c*) manuring; and (*d*) the variety. The following are characters which vary:—(*A*) dry matter; (*B*) starch; (*C*) fat; (*D*) protein; (*E*) crude fibre; (*F*) ash; (*G*) nitrogen free extract; (*H*) cooking quality and flavour; and (*I*) behaviour towards diseases.

With regard to the effect of manuring, Kraft (12) has given a detailed account which is of considerable interest. He states that manuring exercises a very great influence on the composition and finds that of all manures those which have the most marked effect are potassic and nitrogenous manures. To a lesser extent phosphatic and calcareous manures have an influence.

Potash.—In general one-sided potassic manuring decreases considerably the dry matter, starch and protein content but increases the water and mineral content, at the same time acting adversely on the taste. The absence of potash acts in the reverse direction. Kraft, however, is careful to point out that in his experiments he used chloride-containing manures, *e.g.*, kainit and potash manure salts. He states that the potato is highly susceptible to chlorides. He quotes experiments which show similar effects from the use of magnesium chloride and sodium chloride, whereas potassium sulphate actually increases the percentage of starch. The evil effect of the chlorides can, according to the writer, be obviated by autumn applications of such manures. With regard

to the protein content Kraft is uncertain whether the adverse effect is due to the chlorides or to the potash itself. Increased ash content may be due to the chlorides. Other authorities (8), (9), (13), (14), (15) attribute the action of kainit, potash manure salts, etc., to the chlorides and all demonstrate the very beneficial action of sulphate of potash. Very favourable results have been obtained through the use of sulphate of potash-magnesia (8), (16).

Nitrogen.—One-sided nitrogenous manuring increased the protein content but decreased the percentage of ash and crude fibre. On the other hand, if nitrogenous manures are omitted from a mixture, the dry matter, starch and protein contents are lowered while the mineral content is increased. Absence of nitrogen increases susceptibility to scab, while its presence increases scab resistance.

Phosphates.—These did not seem to exercise very much influence. Basic slag, of all the phosphatic manures applied, produced the highest percentage of dry matter and starch, combined with a high protein content. Superphosphate seemed to lower the protein content, while the influence of bone meal was scarcely appreciable.

Farmyard manure and green manuring very favourably affected the composition of the potato.

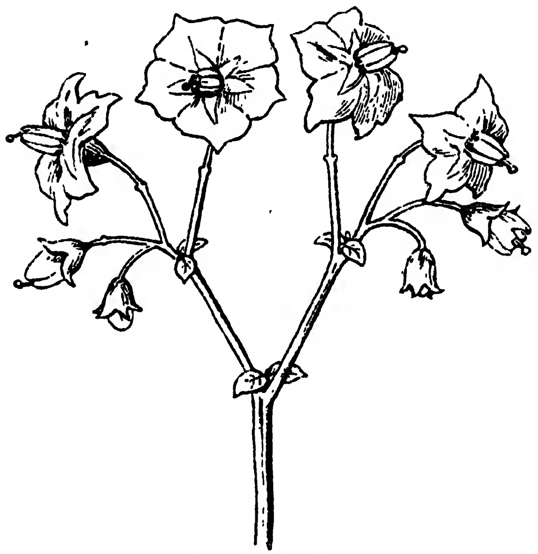
INFLUENCE OF FARMYARD MANURE.—Bornemann (6) considers that one of the most important influences of farmyard manure is to increase the carbohydrate content of the soil and thus provide material for decomposing bacteria, etc., to act upon with resultant increments to the carbon dioxide content of the atmosphere. Increased carbon assimilation, and consequent yield of tubers, is, according to Bornemann, dependent on the available carbon dioxide. He explains the increased yield obtained by farmyard manure and artificials, as compared with artificials alone when like quantities of plant nutrients are supplied, by increased assimilation due to the greater amount of CO_2 present in the atmosphere above ground manured with organic material. As the formation of this gas is greatest during the growing season when the dung is applied in spring, Bornemann deprecates autumn applications for the potato.

Botanical Characters.—An excellent description of the potato plant is given by Snell (7). There is, however, very little information to add to that which we have acquired in this country and which has already been published at various times in leaflet form by this Department. Again, a great many characters have been noticed here which have not been remarked upon in Germany. One of the most interesting features of the German observations lies in the discovery of a connection between the colours of the sprouts and those of the flowers. This may be tabulated as follows:—

Sprout.	*Flower.*
Green.	White.
Pink.	White, Pink, or Reddish Purple.
Purple.	White, Blue, or Bluish Purple.

An analysis of our own varieties seems to confirm the above correlation which, however, has been to a certain extent at least obscured owing to the adoption in this country of trade names for colours of flowers. Other colour connections mentioned by Snell are:—(*a*) White flowers are usually associated with rose coloured tubers; (*b*) varieties with green stems showing no trace of other colouring have white skinned tubers, while (*c*) markedly reddish brown stems are usually associated with coloured tubers. Both (*b*) and (*c*) have been observed and seem to be accurate. No connection such as is indicated in (*a*) has been reported in this country.

Snell considers that the purple colouring on ripe fruit may be a varietal characteristic. This observation seems to be correct: similar experiences have been met with here. Myatt's Ashleaf and Abundance show purple on the plums. It is to be noted, however, that this characteristic may be affected by the weather.



Inflorescence showing Inflorescence Leaflets.

As a possible varietal character Snell mentions inflorescence leaflets.

In this country leafy inflorescences have been noticed, *e.g.*, on the varieties Lord Rosebery, Katie Glover and Dominion, but in these cases the inflorescences are malformed and not regular as in accompanying figure. It is to be noted, however, that there is a possibility of the formation of these leaflets being influenced by external conditions.

Snell draws attention to sensitive and insensitive flowers. Some flowers remain open from early morning till late at night, while others close in the evening, as also at other times according to weather conditions. The fact that most potato flowers are sensitive has been noticed for a considerable time in this country. The varieties Arran Chief, Champion and Crusader appeared during the 1922 season to possess insensitive flowers.

That the cut surfaces of potatoes turn brick red on occasion is a well-known fact. Snell, however, considers that the rapidity and intensity of colouring are varietal characteristics. This observation seems to be accurate: Majestic in this country

during season 1922 turned more rapidly and to a much greater extent brick red when cut than, say, did Golden Wonder.

Conclusions.—The following practical points may be noted for further observation :—

1. Seed from peaty and sandy soils, other things being equal, appears to be preferable to that from heavier land.

2. Seed should only be cut as an emergency measure. In all cases the variety and the nature of the ground must receive serious consideration.

3. It is of advantage to use immature seed or seed from plants which have been cut green.

4. It is possible to influence greatly the culinary quality of potatoes by the system of manuring adopted.

5. Forced potatoes would not appear to make good seed, especially when heavy doses of artificials have been used and more especially when early varieties are in question.

6. It appears possible that the use of CO_2 may induce plants to flower profusely and to set berries.

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CENSUSES OF PEDIGREE STOCK IN SCOTLAND IN 1920 AND 1921.

ACTING in conjunction with the Ministry of Agriculture and Fisheries, the Board undertook inquiries into the numbers of Pedigree Stock in the country in the years 1920 and 1921. In the case of the 1921 census, the information was collected by both Departments on 4th June. The Board's census of 1920 was taken on 31st January, while the relative figures obtained by the Ministry were collected on 15th December 1919.

In January 1920, schedules were issued by the Board to the members of the various Scottish Breed Societies whose names appeared in the books of the respective Societies, requesting information as to the number of Scottish Pedigree Stock owned by them on 31st January. The schedules were sent to the members resident in England and Wales, as well as to those resident in Scotland. In 1921 the census was repeated on similar lines, but on this occasion the date upon which particulars were collected corresponded to the date of the annual agricultural returns, viz., 4th June, and schedules were also issued to the members of the Societies resident in Ireland.

In order to avoid duplication of statistics, the figures regarding animals of the Scottish breeds located in England and Wales were collected by the Board and thereafter communicated to the Ministry for inclusion in the general tabulation of the numbers in each class found in England and Wales. In like manner the figures collected by the Ministry, showing the numbers of English and foreign breeds in Scotland, were transmitted to the Board and are included in the appended tables.

A considerable number of the schedules issued, covering all classes of stock, were returned wholly blank or were in other respects useless for tabulation. It was ascertained later that many of the members whose names were still on the books of the Societies were no longer breeders, having previously sold off their stocks, and this may also account for the fact that a considerable number failed to return the schedules sent to them.

Horses.—Inquiries were addressed to members of the Clydesdale Horse Society and the Shetland Pony Society in 1920 and 1921, the numbers of schedules issued in the two years being 3433 and 4077 respectively. The replies totalled 3122 in 1920 and 3201 in 1921, of which 2756 and 2928 respectively were tabulated.

The Clydesdale is by far the most important pedigree horse in Scotland. Out of the total of 15,841 of all classes returned in 1920, Clydesdales numbered 13,802, while in 1921 this breed accounted for 14,641 of the total of 16,908 for all classes. Shetland Ponies numbered 1764 in 1920 and 1596 in 1921.

Table I. includes details regarding other breeds in Scotland. These figures were collected by the Ministry of Agriculture and Fisheries. It will be observed that, with the exception of Hackneys, the number of horses of English and foreign breeds in Scotland is very small.

The distribution of the pedigree horses in Scotland is shown in Table II. Clydesdales predominate to the practical exclusion of all other breeds of working horses in the country and in this respect the position resembles that of the Shire in England and Wales. The only county from which no return of Clydesdales was received was Shetland, that county apparently confining itself to its own breed of ponies. Of the total of 1596 Shetland Ponies in 1921, Shetland accounted for 834, while 316 were returned in Fife and 112 in Aberdeen.

Cattle.—In 1920 the total number of schedules issued was 1534, of which 1332 were returned. After withdrawing blanks and incomplete schedules there remained 1085 for tabulation. In 1921 the number of schedules issued was 1673 and those returned amounted to 1264. Of this total 1096 were available for tabulation.

The results for both years are summarised in the appended tables. Table III. shows the total numbers of each breed of Pedigree Cattle in Scotland in the years 1920 and 1921, classified according to age and sex, while Table IV. shows the total numbers in each county in Scotland.

It will be seen from the tables that Ayrshires occupy the pre-eminent position in point of numbers, the totals being 33,564 in 1920 and 32,939 in 1921, or, respectively 57 per cent. and 53 per cent. of the total pedigree cattle enumerated. The four south-western counties, Ayr, Dumfries, Kirkcudbright and Wigtown, naturally returned the great proportion of this breed, the home county, Ayr, being credited with almost one-half of the total. The total number for the four counties in 1920 was 29,580 while in 1921 the total was 29,576. The proportion of cows and heifers to bulls—26 to 1—was slightly more than double that of any other breed.

Next in numerical importance, but separated by a wide gap from Ayrshires, are Shorthorns. This breed is found in greatest numbers in the county of Aberdeen, where they amount to just over one-third of the total. The returns show that in 1920 Shorthorns numbered 9181 while in 1921 the total rose to 11,984.

In point of numbers Aberdeen-Angus are not far removed from Shorthorns, the totals being 8452 in 1920 and 8357 in 1921. It will be observed that in 1921 this breed shows a slight decrease in number, whereas Shorthorns show a very marked increase. Aberdeen-Angus are found in largest numbers in the northern and north-eastern counties, Aberdeen returning over one-third of the total, while Banff, Forfar, Inverness, Moray, and Ross and Cromarty taken together account for about one-half.

The numbers of British Friesians increased from 3656 in 1920 to 5014 in 1921. Shetland and Sutherland are the only counties from which no returns were received. The county of Renfrew accounts for 20 per cent. of the total, while fairly large numbers are found in the counties of Ayr, East Lothian, Fife, Forfar, Inverness and Kincardine.

Galloways, which numbered 1904 in 1920, fell to 1814 in 1921, the great majority being recorded in the counties of Dumfries, Kirkcudbright and Wigtown.

Highlands numbered 1764 in 1920 and 1637 in 1921. The breed is almost wholly confined to the counties of Argyll, Inverness, Perth, Ross and Cromarty, and Wigtown, the first named county showing almost one-half of the total.

It will be seen from Table III. that pedigree bulls, one year old and above, numbered 2784 at the date of the census in 1920 and 2806 in 1921, the proportion of these to all bulls used for service in Scotland (as shown in the Agricultural Returns of June 1919 and 1921) being 14·5 and 15·2 per cent. respectively.

Pedigree cows and heifers above one year, formed 9 per cent. of the cows and heifers in milk or in calf at 4th June 1919 and 4th June 1921, respectively.

Sheep.—The number of forms issued in 1920 for the three breeds, Border Leicester, Cheviot and Blackface was 571. Out of a total of 470 replies, only 279, relating to Border Leicesters, were tabulated. Cheviots were omitted from the tabulation as the flock book covered only rams and an examination of the returns showed that the figures entered for the various classes were not sufficiently reliable for statistical purposes. It was not possible to include Blackfaces in view of the fact that there is no flock book in existence.

The forms issued in 1921 numbered 589 and the particulars collected referred exclusively to the Border Leicester and Cheviot breeds. The replies received numbered 430, of which 90 per cent. were available for tabulation.

Table V. shows the total numbers of each breed of pedigree sheep dealt with in the years 1920 and 1921, classed according to age and sex, while Table VI. shows the total numbers in each county in Scotland. In 1920, Border Leicesters were the only Scottish breed finally dealt with and the figures in the tables for that year may be taken as self-explanatory. The following comments refer therefore only to the year 1921.

It will be seen from Table VI. that large flocks of Border Leicesters are to be found in the south-eastern part of Scotland, the counties of East Lothian, Berwick and Roxburgh, taken together, accounting for fully one-fourth of the total for the whole country. This breed is also well represented in the south-western counties, and in Lanark, while considerable numbers are shown in Fife, Forfar, Perth and Aberdeen. No returns in respect of Border Leicesters were received from Argyll, Linlithgow, Selkirk, Nairn, Sutherland, Orkney or Shetland.

Cheviots are numerically strongest in the south-eastern district, the great majority being found in the counties of Roxburgh, Selkirk and East Lothian which together account for two-thirds of the total for Scotland. Flocks in considerable numbers are also found in Lanark and Dumfries, the latter county alone returning nearly one-fifth of the number in the country.

Of the English breeds located in Scotland the most numerous are the Oxford Down and Suffolk. Oxford Downs are found mostly in Roxburgh, East Lothian and Berwick while the counties returning the largest numbers of Suffolks are Dumfries, Berwick, East Lothian and Roxburgh.

In columns 3 and 4 of Table V. for the year 1921 the numbers of flock ewes are given. Column 4 comprises young ewes which, with possibly a few exceptions, had not up to that time been put to the ram. Column 6 shows in the case of Border Leicesters and Cheviots, the approximate number available for replenishing the flocks; in the case of English breeds, ram lambs and ewe lambs were not separately distinguished in 1921. A comparison of the total of Border Leicesters and Cheviots in Column 4 with that in Column 6 tends to show that, in the case of these two breeds, nearly 6,000 pedigree ewes should be available for breeders who do not keep pedigree flocks, and for export.

Pigs.—In view of the fact that there are no pedigree or pure-bred pigs of a distinctively Scottish type, no schedules in respect of pigs were issued by the Board. The returns issued by the Ministry of Agriculture, however, included pedigree English breeds in Scotland, and the tabulated results were subsequently supplied to the Board by the Ministry. The number returned in 1919 was less than half of that returned in 1921, but it must be borne in mind that the censuses of 1919 and 1921 were taken at different periods of the year—December and June respectively—and this may to some extent explain the great disparity between the two totals. Any comparison between the numbers returned is, therefore, valueless.

The returns show that the Large White Yorkshire is the predominating breed in Scotland and that in 1921 practically 50 per cent. were in the three counties of Aberdeen, Linlithgow and Midlothian. The breed next in importance is the Large Black which is found principally in Berwick and Nairn. The full details are given in Tables VII. and VIII.

A comparision of the census figures for December 1919 with the Agricultural Returns, collected at 4th June 1919, indicates that 6·6 per cent. of all the boars used for service in Scotland and 4·6 per cent. of the breeding sows were pedigree animals in breeders' hands. A similar comparison between the census figures and the Agricultural Returns for 1921, collected at the same date, shows that in that year 19·1 per cent. of all the boars used for service and 9·7 per cent. of the breeding sows belonged to pedigree breeds. According to the returns obtained at the two censuses there were in 1919 twenty-five pure-bred sows to four pedigree boars in Scotland, while in 1921 there were nineteen sows to four boars. The Agricultural Returns for 1919 and 1921 show that, taking the totals of breeding pigs in Scotland, there were about nine sows to each boar.

General.—The general results of the two censuses are summarised in Table IX.

A report on the census taken by the Ministry of Agriculture and Fisheries in December 1919 was published in 1921 by H.M. Stationery Office, price 1s. net. The results of the census taken by the Ministry in 1921 are referred to in Part I. of the Agricultural Statistics of England and Wales for the year 1922, published by H.M. Stationery Office, price 1s. 6d. net.

TABLE I.—PEDIGREE HORSES IN SCOTLAND.

31st *January* 1920* *and* 4th *June* 1921.

BREED.	STALLIONS.				MARES.										FOALS.				TOTAL.	
	2 Years Old and above.		1 Year Old and under 2.		5 Years Old and above.		4 Years Old and under 5.		3 Years Old and under 4.		2 Years Old and under 3.		1 Year Old and under 2.		Colts.		Fillies.			
	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.	1920.	1921.
Arab	2	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	3	1
Clydesdale	595	567	326	372	5638	6009	1059	1178	1032	1184	1153	1412	1333	1566	1192	1121	1474	1232	13,802	14,641
Hackney	29	27	17	12	63	89	16	24	10	15	19	21	13	21	19	12	18	21	204	242
Percheron (British)	1	2	...	..	5	12	...	...	3	1	2	...	...	1	1	...	...	2	12	18
Shire	...	5	..	2	...	6	...	1	...	1	...	1	...	4	...	1	...	2	...	23
Thoroughbred	...	7	...	5	...	27	..	3	...	6	...	7	..	7	...	7	...	9	...	78
Ponies—Polo	1	...	1	...	9	1	3	...	...	...	2	...	...	...	3	...	2	...	21	1
„ Highland	..	42	...	10	...	56	...	13	...	16	...	8	...	22	...	11	...	13	...	191
„ Riding	...	...	...	...	1	...	..	...	...	...	...	..	...	...	...	...	...	...	1	...
„ Shetland	165	160	74	120	792	592	121	102	90	115	91	107	130	118	129	129	172	153	1764	1596
Total Pure-bred Horses and Ponies	793	811	418	521	6509	6792	1199	1321	1135	1338	1267	1556	1476	1739	1344	1281	1666	1432	15,807	16,791
Hunter	2	8	...	2	16	56	1	5	2	9	1	8	1	4	8	11	3	14	34	117
TOTAL	795	819	418	523	6525	6848	1200	1326	1137	1347	1268	1564	1477	1743	1352	1292	1669	1446	15,841	16,908

* Census of English Breeds was taken on 15th December 1919.

TABLE II.—PEDIGREE HORSES BY BREEDS AND COUNTIES.

31st *January* 1920* *and* 4th *June* 1921.

COUNTY.	Arab.		Clydesdale.		Hackney.		Percheron (British).		Shire.		Ponies. Highland.		Ponies. Polo.		Ponies. Riding.		Ponies. Shetland.		Thoroughbred.		Total Pure-bred Horses.		Hunter.		TOTAL.	
	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1931	1920	1921	1920	1921
Aberdeen	..	..	1677	1777	..	4	..	2	..	..	..	1	12	..	..	..	97	112	..	5	1786	1901	..	2	1786	1903
Argyll	..	..	496	384	..	..	..	..	..	..	..	36	..	..	..	..	..	9	..	..	496	429	..	..	496	429
Ayr	..	..	1079	1155	35	..	..	..	..	14	..	..	..	..	..	..	25	31	..	23	1139	1223	4	7	1143	1230
Banff	..	..	339	381	1	..	..	..	..	..	..	..	..	..	..	..	1	1	..	..	341	382	..	..	341	382
Berwick	..	..	144	149	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	144	153	..	3	144	156
Bute	..	..	124	125	..	..	..	..	..	..	..	34	..	..	..	..	..	..	..	..	124	159	..	..	124	159
Caithness	..	..	240	193	..	..	..	..	..	9	..	..	..	..	..	..	4	2	..	..	244	204	..	..	244	204
Clackmannan	..	..	148	182	..	51	..	..	..	..	..	..	..	..	..	..	31	38	..	..	179	271	..	..	179	271
Dumbarton	..	..	212	281	1	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	214	281	5	..	219	281
Dumfries	..	..	771	914	..	3	..	4	..	..	..	..	9	..	..	..	37	43	..	10	817	974	..	..	817	974
East Lothian	..	..	235	283	..	..	..	..	..	..	..	..	..	..	..	..	1	1	..	25	236	309	..	..	236	309
Fife	..	..	647	694	..	4	..	..	..	..	..	..	..	1	..	..	273	316	..	..	920	1015	11	1	931	1016
Forfar	..	..	399	387	..	..	..	..	..	..	..	..	..	..	..	..	13	19	..	..	412	406	..	..	412	406
Inverness	..	..	151	173	12	14	..	..	..	..	..	48	..	..	..	..	28	..	..	..	191	235	..	..	191	235
Kincardine	..	..	177	216	7	8	..	..	..	..	..	..	..	..	..	..	13	..	..	..	197	224	..	..	197	224
Kinross	..	..	73	82	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	73	82	..	..	73	82
Kirkcudbright	..	..	925	954	6	1	2	1	..	..	..	..	..	..	..	..	4	5	..	..	937	961	..	..	937	961
Lanark	..	..	1076	1111	71	80	..	..	..	..	..	..	..	..	..	..	54	64	..	..	1201	1255	..	..	1201	1255
Linlithgow	..	..	133	160	43	47	..	..	..	..	..	..	..	..	..	..	..	..	..	..	176	207	..	2	176	209
Midlothian	3	1	280	361	8	5	..	..	..	..	..	..	..	..	..	..	12	2	..	..	303	369	1	2	304	371
Moray	..	..	341	281	2	..	..	..	..	..	..	..	..	..	..	..	6	5	..	..	349	286	..	..	349	286
Nairn	..	..	49	66	..	..	..	..	..	..	..	4	..	..	..	..	..	..	..	..	49	70	..	..	49	70
Orkney	..	..	55	102	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	55	102	..	..	55	102
Peebles	..	..	141	136	..	..	..	..	..	..	..	..	..	..	..	..	19	6	..	..	160	142	..	..	160	142
Perth	..	..	939	1086	3	8	..	..	..	..	..	61	..	..	..	..	76	61	..	..	1018	1216	..	1	1018	1217
Renfrew	..	..	456	501	1	7	..	..	..	..	..	6	..	..	..	..	2	2	..	..	459	516	..	..	459	516
Ross and Cromarty	..	..	337	241	6	4	..	..	..	..	..	..	..	..	..	..	21	16	..	..	364	261	..	..	364	261
Roxburgh	..	..	142	129	..	..	10	11	..	..	..	..	..	..	..	..	7	..	..	9	159	149	13	99	172	248
Selkirk	..	..	9	10	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	2	9	14	..	..	9	14
Shetland	..	..			..	..	..	..	..	..	..	..	..	..	..	..	1020	834	..	..	1020	834	..	..	1020	834
Stirling	..	..	886	880	8	4	..	..	..	..	..	1	..	..	..	..	9	21	..	..	903	906	..	..	903	906
Sutherland	..	..	10	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	10	2	..	..	10	2
Wigtown	..	..	1111	1245	..	..	..	..	..	..	..	..	..	..	..	..	11	8	..	..	1122	1253	..	..	1122	1253
TOTAL	3	1	13,802	14,641	204	242	12	18	..	23		191	21	1	1	..	1764	1596		78	15,807	16,791	34	117	15,841	16,908

* Census of English Breeds was taken on 15th December 1919.

TABLE III.—PEDIGREE CATTLE IN SCOTLAND.

31st January 1920* *and 4th June* 1921.

1	2		3		4		5		6		7	
BREED.	Bulls 1 Year Old and above.		Cows and Heifers 2 Years Old and above.		Heifers 1 Year Old and under 2.		Bulls under 1 Year.		Heifers under 1 Year.		TOTAL.	
	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Aberdeen-Angus	692	429	3759	3868	1228	1187	1403	1409	1370	1464	8452	8357
Ayrshire	1006	959	19,739	19,533	6106	5426	1315	1510	5398	5511	33,564	32,939
British Friesian	199	317	1847	2647	627	874	198	348	785	828	3656	5014
English Kerry and Dexter	1	1	3	3	1	1	1	...	1	1	7	6
Galloway	179	112	903	828	301	316	269	250	252	308	1904	1814
Hereford	...	...	5	...	3	...	...	...	...	...	8	...
Highland	115	102	977	914	268	238	131	121	273	262	1764	1637
Jersey	11	16	84	125	29	41	4	8	28	27	156	217
Lincoln Red Shorthorn	...	3	...	40	...	...	...	16	...	16	...	75
Longhorn	1	3	14	17	2	5	1	8	1	4	19	37
Park	...	4	...	11	...	1	...	4	...	4	...	24
Red Poll	6	16	33	60	7	16	14	8	13	18	73	118
Shorthorn	574	844	4349	5584	1223	1545	1536	2020	1499	1991	9181	11,984
TOTAL	2784	2806	31,713	33.630	9795	9650	4872	5702	9620	10,434	58,784	62,222

* Census of English and other Breeds was taken on 15th December 1919.

TABLE IV.—PEDIGREE CATTLE BY BREEDS AND COUNTIES.

31st *January* 1920* *and* 4th *June* 1921.

COUNTY.	Aberdeen-Angus.		Ayrshire		British Friesian		English Kerry and Dexter.		Galloway.		Hereford.		Highland		Jersey.		Lincoln Red Shorthorn		Long-horn.		Park.		Red Poll.		Shorthorn.		TOTAL.	
	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No	No.	No.	No.	No.	No.	No.	No	No	No	No.	No	No.	No.	No	No.	No.	No.	No.
Aberdeen	2919	2850	29	19	58	83	..								24	31									3488	4158	6518	7141
Argyll	14	10	330	230	55	27	..		1	1			842	721												..	1242	989
Ayr	84	83	15·547	14·134	298	428			81	83					19	19								5			16,029	14,752
Banff	893	975	..		38	16			..																530	607	1461	1598
Berwick	102	141				22										37									66	108	168	308
Bute	..	..	395	249	72	67			..				49	77													516	393
Caithness	132	115	..	..	8	7																			176	277	316	399
Clackmannan	119	79	..		43	63																			75	142	237	284
Dumbarton	..	..	456	531	33	92																			17	..	506	623
Dumfries	69	75	4915	5758	14	23			636	644													41	56	24	38	5699	6594
East Lothian		..			286	359	..			..					4	7							5	5	249	422	544	793
Fife	131	139		..	601	703	..	..							11	16								6	200	261	943	1125
Forfar	727	764	..		158	318							24	30		8								3	307	367	1216	1490
Inverness	703	549		..	135	339							340	350	11	12									545	455	1734	1705
Kincardine	310	287			346	322																			248	195	904	804
Kinross	36	48			26	34																			15	26	77	108
Kirkcudbright			6775	7180	23	15			746	650	8														27	49	7579	7894
Lanark	..	..	1667	1381	211	290	..		..	..					21	13						24	..	20	39	43	1938	1771
Linlithgow	90	91	23	..	33	56									22	21									96	181	264	350
Midlothian	..	..		4	46	63									14	16											60	83
Moray	841	830		..	48	63																			413	400	1302	1293
Nairn	274	300		..	15	22							57	52											105	127	451	501
Orkney	25	4	..	..	..	5																			92	105	117	114
Peebles			..		16	38				22						2									45	63	61	125
Perth	381	433	46	43	68	127							210	146										1	1184	1642	1889	2392
Renfrew	48		693	644	768	1008																				..	1509	1652
Ross and Cromarty	507	541		26	24	52							108	128					19	37			4	7	812	1277	1474	2068
Roxburgh	39	33	..	..	32	46	7	6		18					30	34	..	75							148	164	256	376
Selkirk	..	..		..	..	4	..	..																			..	4
Shetland	..		..	..			..	..																			..	..
Stirling		10	345	236	191	289			62	54			28	32									23	9	256	255	905	885
Sutherland									..														..	6	24	31	24	37
Wigtown	8	..	2343	2504	10	33			378	342			106	101												591	2845	3571
TOTAL	8452	8357	33·564	32,939	3656	5014	7	6	1904	1814	8		1764	1637	156	217	.	75	19	37		24	73	118	9181	11,984	58,784	62,222

* Census of English Breeds was taken on 15th December 1919

TABLE V.—PEDIGREE SHEEP IN SCOTLAND.

31st January 1920* *and 4th June* 1921.

1.	2.		3.		4.		5.		6.		7.	
BREED.	Rams, 1 year old and above.		Ewes. 2 years old and above.		Ewes. 1 year old and under 2 years.		Lambs, under 1 year. Rams.		Lambs, under 1 year. Ewes.		TOTAL.	
	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921
	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.	No.
Border Leicester . .	334	2619	4306	4975	2028	2610	3131	3825	3123	4023	12,922	18,052
Cheviot	...	1965	...	29,587	...	8163	...	2219	...	12,561	...	54,495
Kent or Romney Marsh	...	6	...	14	...	3	...	23†	...	†	...	46
Oxford Down . .	57	708	893	1499	419	709	541	2129†	590	†	2500	5045
Shropshire . . .	17	161	189	244	45	142	154	364†	169	†	574	911
Suffolk . . .	17	51	414	805	152	531	38	1226†	284	†	905	2613
TOTAL . .	425	5510	5802	37,124	2644	12,158	3864	9786†	4166	16,584†	16,901	81,162

* Census taken on 15th December 1919.

† Ram lambs and ewe lambs were not separately distinguished in 1921.

TABLE VI.—Pedigree Sheep by Breeds and Counties.

31st January 1920 and 4th June 1921.*

County.	Border Leicester.		Cheviot.		Kent or Romney Marsh.		Oxford Down.		Shropshire.		Suffolk.		Total.	
	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921	1920	1921
Aberdeen	792	1,582	...	...	...	...	12	25	...	...	56	87	860	1,694
Argyll	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ayr	756	1,160	...	...	...	...	...	...	...	...	...	...	756	1,160
Banff	115	213	...	...	...	...	...	...	...	...	47	...	162	213
Berwick	1,079	1,068	...	1,112		...	615	1210	...	...	196	557	1,890	3,947
Bute	9	11	...			...	...		...	...	...	...	9	11
Caithness	362	513	...	846		...	...	...	...	...	...	...	362	1,359
Clackmannan	306	374	...	...	...	...	...	...	...	...	...	...	306	374
Dumbarton	22	32	...	...	...	...	...	...	...	...	...	...	22	32
Dumfries	292	355	...	10,186	...	...	...	...	...	...	309	827	601	11,368
East Lothian	1,743	2,420	...	3,982	...	...	786	1585	...	...	81	541	2,610	8,528
Fife	1,147	892	...	...	...	...	37	230	...	...	...	...	1,184	1,122
Forfar	1,546	2,710	...		...	...	...	...	574	911	...	74	2,120	3,695
Inverness	451	293	...	...	...	...	...	...	...	...	...	...	451	293
Kincardine	101	254	...	...	...	...	...	...	...	...	...	...	101	254
Kinross	11	137	...		...	...		...	...	...	...	...	11	137
Kirkcudbright	353	331	...	182	...	...	147	...	...	...	...	...	500	513
Lanark	741	1,307	...	4,915	...	...	...	...	...	...	35	86	776	6,308
Linlithgow	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Midlothian	335	299	...	309	...	...		...	...	...	...	...	335	608
Moray	247	197	...	...	...	...	...	...	...	...	...	...	247	197
Nairn	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Orkney	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Peebles	263	318	...	563	...	...	58	102	...	...	...	...	321	983
Perth	960	1,698	...	...	...	46	...	...	...	...	...	91	960	1,835
Renfrew	38	9	...	...	...	...	...	...	...	...	...	...	38	9
Ross and Cromarty	85	59	...	...	...	...	...	...	...	...	...	53	85	112
Roxburgh	791	1,120	...	21,801	...	...	845	1893	...	...	181	297	1,817	25,111
Selkirk	...	...	...	10,278	...	...	...	...	...	...	...	...	...	10,278
Shetland	...		...	...	...	...	...	...	...	...	...	...	...	...
Stirling	42	92	...	...	...	...	...	...	...	...	...	...	42	92
Sutherland	...	...	...	321	...	...	...	...	...	...	...	...	...	321
Wigtown	335	608	...	...	...	...	...	...	...	...	...	...	335	608
Total	12,922	18,052	...	54,495	...	46	2500	5045	574	911	905	2613	16,901	81,162

* Census of English Breeds was taken on 15th December 1919.

TABLE VIII.—PEDIGREE PIGS BY BREEDS AND COUNTIES.

15th December 1919 *and 4th June* 1921.

COUNTY.	British Berkshire.		Cumberland		Gloucester Old Spots.		Large Black.		Large White Yorkshire.		Middle White Yorkshire.		Tamworth.		TOTAL.	
	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921
Aberdeen	...	...	...	...	...	...	13	55	79	366	...	17	...	...	92	438
Argyll	...	...	11	5	...	...	...	8	...	41	...	...	...	...	11	54
Ayr	...	...	18	18	...	...	5	98	39	150	3	3	...	...	65	269
Banff	...	2	...	...	...	...	...	...	...	5	...	...	...	...	...	7
Berwick	...	...	...	15	...	10	11	169	...	...	...	12	...	...	11	206
Bute	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Caithness	...	...	11	...	...	...	...	40	...	...	...	...	...	...	11	40
Clackmannan	...	...	...	...	...	...	...	10	...	8	...	...	...	...	...	18
Dumbarton	...	...	...	...	...	...	...	...	53	...	...	...	...	...	53	...
Dumfries	...	...	32	35	...	...	4	36	76	57	...	9	...	13	112	150
East Lothian	...	...	61	6	...	...	...	...	...	13	...	...	...	...	61	19
Fife	...	...	...	3	...	...	...	14	86	143	...	54	...	...	86	214
Forfar	39	12	...	...	...	...	...	53	11	38	13	9	...	...	63	112
Inverness	11	39	...	...	...	13	...	21	...	5	...	...	...	...	11	78
Kincardine	...	...	...	...	...	...	...	6	...	26	...	...	...	...	...	32
Kinross	...	...	...	...	...	...	...	...	24	...	5	...	...	...	29	...
Kirkcudbright	...	...	...	...	...	1	...	3	...	...	...	...	...	2	...	6
Lanark	103	100	...	...	...	...	...	61	71	133	...	6	...	...	174	300
Linlithgow	43	18	...	...	...	...	...	...	118	311	85	77	...	...	246	406
Midlothian	...	...	...	...	...	...	...	5	338	476	...	...	...	...	338	481
Moray	...	...	...	...	...	...	...	12	...	85	...	...	...	...	...	97
Nairn	...	4	...	...	...	...	87	178	...	7	...	...	...	...	87	189
Orkney	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Peebles	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Perth	...	...	...	...	...	...	...	...	...	...	27	...	...	...	27	...
Renfrew	...	24	...	...	...	...	...	78	48	162	21	159	...	...	69	423
Ross and Cromarty	12	...	...	...	...	...	...	13	...	150	...	8	...	...	12	171
Roxburgh	...	...	...	...	...	...	...	41	...	9	...	...	...	...	...	50
Selkirk	...	15	12	26	...	...	...	...	15	61	...	...	...	...	27	102
Shetland	...	...	...	...	...	...	...	24	...	...	...	...	...	...	...	24
Stirling	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sutherland	...	...	...	...	...	...	40	35	...	31	21	64	...	...	61	130
Wigtown	...	...	...	...	...	...	...	...	2	95	...	...	...	...	2	95
TOTAL	208	214	145	108	...	24	160	960	960	2372	175	418	...	15	1648	4111

TABLE VII.—PEDIGREE PIGS IN SCOTLAND.
15th December 1919 and 4th June 1921.

1	2		3		4		5		6	
Breed.	Six Months Old and above.				Under Six Months.				Total.	
	Boars		Sows and Gilts.		Boars.		Gilts.			
	1919	1921	1919	1921	1919	1921	1919	1921	1919	1921
British Berkshire	14	23	92	70	36	37	66	84	208	214
Cumberland	10	12	51	65	15	8	69	23	145	108
Gloucester Old Spots	...	3	...	10	.	1	...	10	..	24
Large Black	9	85	54	366	45	178	52	331	160	960
Large White Yorkshire	64	213	442	1053	139	269	315	837	960	2372
Middle White Yorkshire	13	31	52	173	56	48	54	166	175	418
Tamworth	..	1	...	5	...	5	..	4	..	15
Total	110	368	691	1742	291	546	556	1455	1648	4111

TABLE IX.

Pedigree Animals of Certain Breeds in Scotland in 1920 and 1921.

CATTLE.

Breed.	*1920.*	*1921.*
Aberdeen-Angus ...	8452	8357
Ayrshire	33,564	32.939
British Friesian ...	3656	5014
English Kerry and Dexter	7	6
Galloway	1904	1814
Hereford	8	..
Highland	1764	1637
Jersey	156	217
Lincoln Red Shorthorn	...	75
Longhorn	19	37
Park	...	24
Red Poll	73	118
Shorthorn	9181	11,984
Total	58,784	62,222

SHEEP.

Breed.	*1920.*	*1921.*
Kent or Romney Marsh	...	46
Oxford Down ...	2500	5045
Shropshire	574	911
Suffolk	905	2613
Border Leicester ...	12,922	18,052
Cheviot	*	54,495
Total	16,901	81,162

PIGS.

Breed.	*1920.*	*1921.*
British Berkshire	208	214
Cumberland ...	145	108
Gloucester Old Spots	...	24
Large Black	160	960
Large White Yorkshire	960	2372
Middle White Yorkshire	175	418
Tamworth	...	15
Total	1648	4111

HORSES.

Breed.	*1920.*	*1921.*
Arab	3	1
Clydesdale	13,802	14,641
Hackney	204	242
Percheron (British) ...	12	18
Shire	...	23
Thoroughbred ...	...	78
Polo Ponies	†22	1
Highland Ponies ...	.	191
Shetland Ponies ...	1764	1596
Hunter	34	117
Total	15,841	16,908

* Figures for Cheviot Sheep for 1920 not available.
† Includes one returned as a Riding Pony.

Smut in Oats and Barley.

A FEW years ago many reports were received from farmers all over the area served by the North of Scotland College of Agriculture that their oat and barley crops were considerably damaged by smut. This led to the laying out of an extensive series of trials at Craibstone for the purpose of determining the relative values of the different methods of treatment usually recommended for preventing or checking this disease. The following is a short account of the methods employed and the results with smutted oats. Five different methods of treatment have been under trial, viz.:—

1. Moistening the seed with solutions of copper sulphate;
2. Moistening the seed with solutions of formalin;
3. Steeping the seed in hot water;
4. Mixing the grain with dry copper carbonate;
5. Applying napthalene to the soil.

1. *Copper Sulphate Treatment.*—In the first season solutions of copper sulphate of two strength, viz., 1 lb. and ½ lb. per gallon of water, were tried. The grain was spread out on the granary floor and the solution sprayed on it, the grain being turned well in order to ensure that all the seeds were well moistened on the outside and then spread out to dry thoroughly before sowing. In both cases it was found that, although these solutions were effective in killing the spores of the smut, they did considerable damage to the seed, the germination being perceptibly lowered. Grain treated with the same solution was dusted with lime, as it had been suggested that this would prevent the copper sulphate doing any harm to the grain. This was found to be quite true, but, on the other hand, the dusting with the lime prevented the treatment being effective, as there were many smutted heads in the plots seeded with this grain. In the following seasons weaker solutions were tried, viz., ¼ of a lb. and ⅛ of a lb. per gallon of water and, as with the strong solutions, part was treated with lime and part untreated. Here it was found that the weaker solutions, even without lime, did not destroy all the spores of the fungus, as all plots contained a good many smutted heads, but, on the other hand, these solutions did no harm to the grain. The general conclusion come to, therefore, is that copper sulphate is not an effective method of treatment. If the solution is sufficiently strong to kill the spores of the fungus it will injure the grains, and if lime is used to prevent this then the spores will not be killed.

2. *Formalin Treatment.*—Solutions of formalin of two strengths have been used, viz., 1 part formalin to 100 parts water and 1 in 200, that is, approximately, 1 pint of formalin to 12½ gallons of water and 1 pint to 25 gallons of water respectively. These solutions were applied to the grain by the same method as with the copper sulphate solutions described above. Half the treated grain, however, in each case was spread out immediately to dry, while the other half was covered up with bags, and, therefore, kept in a more or less moist condition for about twenty-four hours. There did not appear, however, to be any advantage in covering

up the grain, as both solutions, covered or uncovered, proved equally effective. During the five seasons these methods have been under test no smutted heads have been found in any of the plots seeded with the treated grain, and even the stronger solution did no damage to the germination.

3. *Dry Copper Carbonate Treatment.*—Powdered copper carbonate was mixed with the grain in quantities varying from 1 oz. to 8 oz. per bushel. This treatment has certainly the advantage of entailing very little trouble, as the grain is not damped in any way. Unfortunately, however, it was found that in no case had the treatment any effect on the smut, although, on the other hand, it did no damage to the grain.

4. *Hot Water Treatment.*—Here, the grain was steeped in water kept as nearly as possible at a temperature of between 130 and 137 deg. F. for about ten minutes. This method proved quite effective against the spores of the fungus, and did not in any way injure the germination of the grain. But the method was found very difficult of application. Even where a small quantity of grain was used great trouble was experienced in keeping the water at the proper temperature. This method, too, entails more labour than the methods described above, and, therefore, does not appear to be one that can be recommended unless special plant is available for the purposes of treatment.

5. *Napthalene Treatment.*—Ordinary commercial napthalene at the rate of 2 to 5 cwt. per acre was applied to the soil and well harrowed in immediately before the seeds were sown. In all cases it was found that this had no effect on the smut, but that even the 2 cwt. per acre lowered the germination of the grain very considerably.

Looking to the results of these tests carried on for the past five seasons, there is no doubt as to the superiority of the formalin method of treatment. Not only is it very effective, but it is at the same time easily applied, and is comparatively cheap, 1 pint of formalin to 25 gallons of water, that is 1 in 200, is sufficient to treat 40 to 50 bushels of grain, and at the present price of formalin this will not cost more than 1½d. per bushel. In order, however, that the treatment may be thoroughly effective, care must be taken to see that the seeds are all well moistened on the outside by repeatedly turning the heap of grain, and are thoroughly dried afterwards.

While the above refers to the trials with oats, similar trials were carried out with barley during the same time. Now, it is held by many that while in the case of oats the spores of the fungus are sown along with the grain, and infection therefore takes place while the oat plant is in the seedling stage, with barley, on the other hand, infection takes place through the flower, and the fungus is therefore already in the grain at the time of sowing. If this were the case, then the methods of treatment described above would naturally be ineffective. So far, however, as the trials at Craibstone are concerned, the treatment has been quite as effective with barley as with oats.

Poultry-keeping as a School Subject.

AN examination of the census returns of young persons between the ages of 14 and 18 showed that in Berwickshire a very large proportion of the boys and girls leaving school take up some form of farm work, hence there was suggested the desirability of instituting for post-qualifying pupils a practical course bearing on farm and garden work. Clearly there was a case for giving to an agricultural course consideration not less favourable than that given to the domestic course or the industrial course of a supplementary department.

The Edinburgh and East of Scotland College of Agriculture was favourably disposed towards the scheme, and anxious to direct its extension work along the lines suggested. To encourage rural science centres the College made proposals for providing at a moderate cost instruction in agriculture, horticulture and poultry-keeping. The Education Authority, after considering a draft scheme put before them, decided to set up a rural science course at Duns Public School.

Towards the end of March 1921, half an acre of a meadow adjacent to the playground was rented, and the area enclosed on all sides by wire-netting. An area of 450 square yards was fenced off as a double poultry-run, the remainder being ploughed and planted with potatoes. It is interesting to note that the return from this crop, sold locally, more than met the expenditure in connection with the operations for the permanent lay-out of the ground, and also the cost of a large number of fruit trees, bushes, seeds, manures, etc. The school already possessed the necessary gardening tools, but the provision necessary for live stock presented some difficulty. In his proposals for the inclusion of poultry-keeping in the curriculum the headmaster suggested to the Education Authority three options:—(1) Poultry house, appliances, fowls, feeding stuffs, etc., to be purchased by the Authority, and arrangements to be made by the Authority for the care and feeding of their stock and the marketing of the eggs, etc. (2) Poultry house and appliances to be purchased by the Authority: the headmaster to provide fowls, feeding stuffs, etc., to be responsible throughout the year for the care and feeding of the stock, and in return to receive the eggs. (3) The headmaster to provide poultry house, appliances, fowls, feeding stuffs, etc., and to lend these for the purposes of the class: the headmaster to be responsible throughout the year for the care and feeding of the stock, and to receive the proceeds arising from the sale of fowls, chickens and eggs. Option No. 3 was agreed to, with the proviso that the Authority would take over at valuation the stock and appliances on request being made at any time by the headmaster. Where, as in this case, the headmaster is actively interested in poultry-keeping, it is desirable that full responsibility for capital outlay on stock and appliances should be his personal concern. He may then take up chick-rearing, egg production, or breeding of pedigree stock, and find in one or other of these directions recompense for his energies.

By the middle of April 1921, a tool shed had been converted into a hen house and moved into the new poultry run. The

essential appliances having been provided by the headmaster, a valuation taken at 1st May by a representative of the College of Agriculture gave the following figures:—

House - - - - - - - -	£9	0	0
Grain chest - - - - - -	0	12	0
Double sitting box - - - - -	1	5	0
Two large coops - - - - - -	4	0	0
Two small coops - - - - - -	1	10	0
Brooder - - - - - - - -	3	0	0
Feeding basins, trays, scraper, etc. -	0	14	0
Ten hens and one cock - - - -	8	10	0
TOTAL - -	£28	11	0

The course of instruction so far has dealt with:—

1. Housing of poultry—ventilation, lighting, cleanliness and floor space.
2. Size, cropping and cleanliness of run.
3. The broody hen and its management.
4. Chickens—hatching, feeding and management.
5. Incubators and brooders.
6. Breeds of poultry.
7. Poultry foods—method and cost of feeding.
8. Digestive system of fowl.
9. Egg production.
10. Poultry hygiene.

Practical and theoretical lessons are given by the College Instructress. The subject provides opportunity for much correlated work. The woodwork lesson has been utilised for such constructional work as the making of gates, coops, nest boxes, sitting boxes, grain chest, hoppers, feeding trays, barrow, etc. The conversion of a tool shed into a hen house proved a valuable lesson, as it demonstrated that an ordinary outhouse could be made a satisfactory abode for fowls, provided due attention were paid to the following points:—moveable nest boxes, perches and dropping board, ventilation without draughts, and satisfactory lighting of the floor area. Many points of practical interest emerged in planning the routine work. The great stress laid on the need for absolute cleanliness led to recognition of the advantages of certain appliances and the value of systematic arrangement of work. The relative merits of various scratching materials soon became apparent. Preference was given to clean straw litter for the floor as, when renewal became necessary, the broken straw made excellent cover for the dropping board, supplying finally a useful admixture for the hen manure. Careful note was taken of the amount of grain that was readily taken up at a meal, and calculation made of the average quantity required per fowl per meal.

Great interest was displayed by the pupils in all the work, and particularly in such parts of it as the keeping of egg records, the use of the incubator, the home-made brooder, etc. The usual difficulties were encountered, but the overcoming of them proved of real educational value.

Indoors the pupils had regular lessons, involving drawing, weighing, mounting, charting, etc. Sample foods, etc., put up in glass tubes can be readily handled. Estimation of costs and the recording of income and expenditure proved to be useful exercises. The value of house scraps and garden produce led to the suggestion that pupils might endeavour to have fowls or chicks of their own, and they were encouraged to make enquiry concerning difficulties met with. Lessons on plucking and trussing are to be combined with lessons on the various ways of cooking fowls. From the experimental plots used in the teaching of agriculture some wheat, barley and oats were obtained, together with sufficient straw to serve several months. The horticultural plots provide an ample supply of the most suitable green foods.

A very satisfactory feature of the course has been the direct interest taken in the work by many adults. One or two public demonstrations were arranged, and practical lectures given in the poultry runs. Following on these and the inspection of a new hen house in which the headmaster has incorporated some novel arrangements of value, it is interesting to record that quite a number of local poultry breeders have re-modelled their hen houses, and have commenced the selection of breeding pens on much more satisfactory lines.

So far the work has been carried on experimentally and by the most economical means known, but under this system of using odds and ends the training is not less satisfactory than it would be under expensive provision. Throughout the scheme the educational standpoint is never forgotten, and the child who is never likely to pass the qualifying examination is given an opportunity of joining his more intellectual schoolmates in the work of the course. It is hoped to develop a three years' course in the rural science subjects referred to, and to complete a curriculum in one of the directions indicated in Circular 44 of the Scottish Education Department.

Where a rural schoolmaster has a very large garden and already keeps poultry, the initial outlay by the Education Authority may be almost nil. Income from the fowls will balance expenditure, and the subject may become self-supporting.

Variations in Numbers of Sheep.

THERE has been a certain decline in the numbers of sheep in Great Britain within the last say, thirty years, the reduction being relatively less in Scotland than in England. In 1885 there were in England 16,809,778 sheep, and in 1921, 10,614,636. In Wales there were at these two dates 2,767,659 and 3,216,877 sheep respectively; in Scotland there were in 1885, 6,957,198, and in 1921, 6,658,511. There is no very great difference between the two Scottish figures, but this does not mean that there has been an equilibrium round six and three-quarter millions during the whole time. The figure for 1921 was the lowest for any year since 1886 except 1920, and 1921 showed an increase of nearly 300,000 on the previous year, which was half a million below the average from 1911 to 1920.

On the whole, one may say that the decline in the sheep stocks in Scotland was due mainly to the disturbed conditions caused by the War, during which too there happened to be two bad lambing seasons. On the whole, then, Scotland has rather to be taken with Wales, where there has been an increase of nearly a quarter of a million during the period under review, than with England, in which, as a whole, there has been a decline of about six millions in the period.

A further examination, however, shows that in the English counties north of the Humber sheep stocks, on the whole, have been kept up. Thus Northumberland in 1921 had 1,049,225 sheep as against 935,874 in 1885. Similarly, Cumberland had 558,819 as against 494,553; Westmorland, 388,566 as against 332,000; while the decline in Lancashire and the North and West Ridings was only slight.

Substantially, then, one may say that in Scotland, England north of the Humber, and in Wales, the numbers of sheep were practically maintained. The decline, however, was well marked in the other parts of England, where sheep farming has been a prominent feature of the agriculture. Two such regions may be distinguished. The first is constituted by the eastern counties from the Humber down to the Thames, the other by the southern counties, where Downs are common. In the first region there were large decreases in the Lindsey and Kesteven parts of Lincoln, from one and a quarter millions to about 600,000: in Norfolk from nearly 590,000 to 275,000; in Suffolk from 447,000 to less than 200,000; and in Essex from 341,000 to 105,000. Leicester, though a less arable county than the others mentioned, is geographically near Lincolnshire, and the decline there is considerable, from 322,000 to rather less than 190,000. The other group of counties stretches along the south coast. In Kent there was a drop from about 1,020,000 to 684,000; in Sussex from 537,000 to rather less than a quarter of a million; in Hampshire from 525,000 to 163,000: in Dorset from 460,000 to 211,000: in Devon from about 875,000 to about 680,000; in Cornwall from over 450,000 to 280,000; in Somerset from 601,000 to 285,000; in Wiltshire from 660,000 to a little over 200,000; in Gloucestershire from 393,000 to 213,000

Before seeking to interpret these figures it may be useful to consider whether there has been an uninterrupted movement in the directions indicated over the whole period. This does not seem to have been the case. Thus in 1908 there were only about a million fewer sheep in England than in 1885, whereas in Wales there were a million more and in Scotland nearly half a million more than at that date. The year 1908, however, seems to have marked a period of recovery, as the sheep population of Great Britain at that time was a million more than the average for the ten years 1898 to 1907. What is interesting, however, is that in 1908 Scotland, Wales and the North of England were the regions in which sheep were holding their own or actually up in numbers as compared with 1885, and at that time the whole of Yorkshire shared in the upward movement as also did Shropshire. The eastern counties had not lost much, and in Leicester the figures were up a little.

The loss, then, at that date, was greatest in the south and south-western counties, from which in this connection Devon falls to be excepted as there was a slight increase in that county.

The main inference to be drawn from these statistics appears to be that the numbers of sheep have been maintained in the districts where breeding stocks are kept on hill sheep farms where there is very little arable ground. On such farms very little fattening is done, the wether lambs and cast ewes being sold off to be fattened on low ground farms.

Hence any changes in British agriculture due to a decline of arable farming will not greatly affect these areas and, if the sheep stock in other parts of the country declines, the hill sheep farmer, whose costs of production are as low as those in any type of farming can be, gets a positive profit out of farming on land which has no value except in providing moderately good grazing for the hardier breeds of sheep.

On the other hand, in the districts of high arable farming to be found on the east coast of England and Scotland, the sheep are mainly bought in as flying stock to feed on the turnips, and are, in fact, largely incidental to arable cultivation.

Hence the decline of the sheep stocks in these districts should not be very great, because the contraction of the arable area has not been so marked in these districts as in the midlands, west midlands, south-eastern and south-western counties of England.

Possibly, then, the reduction in the sheep population in such counties as Norfolk, Lincoln and the East Riding is due partly to the greater difficulty of getting flying stocks of sheep, through the decrease of breeding stocks in the midlands of England.

The greatest decline in arable cultivation was in the midland, west midland and south-eastern groups of counties, and next in the south-western counties and the north. The south-eastern include Kent, Sussex and Hampshire, the west midlands Gloucester and Wiltshire, the south-western Somerset, Dorset and Devon, all of which are counties where down sheep farming is common, a great part of these counties being on chalk or oölite.

This system may be said to be about half way between the association of sheep feeding with pure arable farming in the east and the pure hill sheep farm of the north and west. On the down system the sheep alternate between the down and the turnips, and it seems only fair to connect the great drop in the sheep population in this big area with the decrease of the area under arable cultivation. One cannot say that in these districts sheep farming or sheep keeping is an incident in arable farming, but the two meet on a more or less equal footing. Thus, if the root crop be the key of the rotation, the decline in arable cultivation will show itself in a decrease in that crop, which, when fed to sheep, helps to maintain the fertility of the land. Hence the reduced numbers of sheep over these big stretches of country tend to confirm the view that you do not get more stock but less stock through a decline in arable farming.

This result is particularly unfortunate because, whereas the combination of arable farming and stock keeping is undoubtedly costly where bullocks are concerned owing to the great amount

of artificial feeding given to them, the English system, combining arable farming with sheep folded on turnips, is a relatively cheap way of securing the same results, and it will be a great misfortune for British agriculture if it breaks down.

Agricultural Conditions.

THE weather during December was mild and open, and cultivation was well forward at the end of the year. The month of January was also unusually mild, but in many districts the rainfall was heavy, and ploughing was interrupted to a greater or less extent. The conditions during February were unfavourable for outdoor work; high winds and rain were prevalent, and some snow fell in most parts about the middle of the month. Owing to the heavy rainfall and the absence of frost the soil was in a heavy state generally, and the normal work of the season was made more difficult. In all parts outdoor work was interrupted, and in many districts in the northern, central and western counties ploughing fell into arrear. In the eastern and south-eastern counties the conditions were not quite so unfavourable and fair progress was made, but here, as elsewhere, delay was caused owing to the heavy rainfall and the wet state of the ground. In Ayrshire the planting of the early potatoes was delayed owing to unfavourable weather and the sodden condition of the soil.

Wheat-sowing was finished in many districts early in December, and the work was completed generally by the end of the month. The seed was sown in good order in all cases; the crop has, on the whole, progressed satisfactorily, and the present prospects are quite up to the average. The braird is vigorous and healthy in most cases, but in a few districts the plant has been checked to some extent owing to the continuance of wet weather. The area sown this year will probably show a slight diminution as compared with last year, but no reliable estimates are yet available.

The condition of last year's potato crop is fairly satisfactory. Considerable loss, however, occurred in North Ayr owing to rot, while in some other districts the crop was damaged by frost in October and the keeping qualities were impaired. Elsewhere potatoes are reported to be in sound condition, and comparatively free from disease, but, owing to the mild season, sprouting in the pits has been more prevalent than usual. In many districts there are large stocks of potatoes on hand, and in some cases they are being fed to cattle.

Live stock have wintered well generally, and pastures have been fairly plentiful. Ewes on arable farms are in good condition, but hill ewes suffered somewhat owing to the wet and stormy weather during January and February. Lambing was in progress at the end of February on arable farms in Forfar, Fife, the Lothians, Berwick, Roxburgh, North Ayr, Dumfries and in sheltered parts of Aberdeen and Perth, chiefly amongst special flocks. Elsewhere, lambing generally had not commenced at the end of February. The fall of lambs so far is satisfactory, and lambs are reported to be strong and healthy.

The supply of turnips is ample except in North Ayr, Skye and Dumbarton. The crop has, on the whole, kept well, but in South-East Perth many of the roots are partially rotten, while in Kincardine those early stored have deteriorated considerably. In several districts, owing to the open winter, the unlifted turnips grew too much, and in some cases ran to seed. Keep of all kinds is fairly plentiful, but in North-East Forfar straw is scarce.

The supply of regular labour is generally ample for present requirements; in Aberdeen, the Lothians, Peebles and Caithness some men are still unemployed.

Weather Forecasts for Farmers.

THE Meteorological Office have recently issued a circular regarding the summer service of forecasts of weather for agricultural purposes. Particulars of the service for last year were given in the *Journal* for April 1922 and the present arrangements are on the same lines. Particulars may be obtained from the Director, Meteorological Office, Air Ministry, Kingsway, London, W.C.2.

RECENT PERIODICAL LITERATURE.

A number of the following extracts and summaries are taken from recent bulletins of the International Institute of Agriculture. Full references to the bulletins, and to the original publications quoted therein, may be obtained on application to the Secretary, Board of Agriculture for Scotland, York Buildings, Edinburgh.

Fixation of Nitrogen by the Wheat Plant. *Nature.*—Lipman and Taylor announce (*Science*, November 24) that they have proved conclusively that wheat plants can fix nitrogen from the air in amounts up to 21 per cent. of the total nitrogen content of the plant. The publication of the evidence upon which this startling announcement is made will be eagerly awaited by agricultural research workers, modifying as it does much of the theory upon which current practice in the use of nitrogenous fertilisers is based. The classic researches of Lawes and Gilbert in the eighties of last century have long been deemed to have proved conclusively that the leguminosæ alone of cultivated plants have the faculty of fixing atmospheric nitrogen, a power which they exercise not directly but through the agency of the nodule organisms on their roots. In their preliminary note in *Science*, the authors recall that one of the heresies maintained many years ago by Jamieson was that all green plants have the power of fixing atmospheric nitrogen (Rept. Agr. Res. Assn., Aberdeen 1905). It is interesting to note that another of the heterodox views held by this veteran worker was that plants have the power of directly absorbing "insoluble' phosphates. The availability of such substances as plant food is no longer in doubt, and, whatever the mechanism of their entry may be, it is now admitted by botanists and soil chemists that many substances insoluble in water can find their way into plant tissues. Jamieson's facts, therefore, appear to have been right in this case also, although his deductions from them may have been unsound.

Smooth-Awned Barleys. *H. K. Hayes and A. N. Wilcox, Jour. of the American Soc. of Agron.*—Farmers find the presence of awns in wheat and barley uncomfortable in handling, and for this reason breeders have devoted much of their attention to the production of awnless varieties. It has,

however, to be noted that the awns have definite physiological functions which have been brought out by several investigators. If the awns are removed a quite noticeable reduction takes place in transpiration, which is particularly active at the time of carbohydrate formation in the seed, which it appears to stimulate. A reduction of about 10 per cent. also occurs in the volume and weight of the seed according to Perlitius, while the spikes become brittle owing to the deposition of dry matter which in the case of normal spikes takes place largely in the awns according to Harcan and Antony.

It is still more important that awnless varieties give a smaller yield than awned as has been discovered by Grantham for wheat, and proved by experiments carried out at the Minnesota Station with awned and awnless hybrids resulting from the same crossings.

Attempts have been made to obtain the physiological advantages of the awns, and at the same time to eliminate the discomforts they cause in handling by cultivating varieties of wheat and barley with smooth or flexible awns, which at present have merely a botanic value. Harlan is responsible for this solution, which has been studied for several years at the Minnesota Station, where varieties of barley with smooth awns have, in certain years, produced a fair yield ; in other years the yield has been considerably reduced, as these varieties show themselves highly susceptible to *Helminthosporium sativum.*

New crosses and more resistant strains have now been tested. In 1920 and 1921 an average yield was obtained superior to that of Manchurian barley which is awned. These varieties have also given good transpiration results, one gramme of water per hour for ten heads of smooth awned barley and also for Manchurian, while certain barleys, both awned and awnless, gave much less. The new varieties, therefore, seem to be very promising.

Sawflies Damaging Cereals in Britain. *A. Roebuck, Bull. Entomological Research, January 1923.*—For several years the author has observed the presence of leaf-eating sawflies upon crops of oats and wheat. The sawfly larvæ, which cause the damage, occur in June and July, and feed along the edges of the leaf-blades generally, also cutting off the extreme portion of the leaf. In the latter half of July the larvæ forsake the growing plant and pupate in the soil, from whence they emerge in May of the following year. The hatching of the adults revealed the fact that two species were involved—*Pachynematus clitellus*, Lap., and *Dolerus hæmabotis*, Klug. One female of the latter species was seen to oviposit along the edge of a leaf, placing some sixty-four eggs at irregular intervals within the tissues of the leaf in openings made by the "saws." The larvæ hatched in three or four days. Although adults of both species are common and apparently widely distributed in Britain, the economic damage caused by the larvæ can be regarded as only of very slight significance.

Thrips or "Bladder-Feet" in Corn. *F. V. Theobald, Jour. Kent, Farmers' Union, 1922.*—During the past season wheat and oats in Kent were seriously damaged by two species of the small, active insects known as Thrips. The damage was due to the insects sucking the plant juices by piercing the tender parts of the ear, and resulted in the discoloration and shrivelling of the ear, and the total loss of the grain in the discoloured area. Further loss, not at first apparent, was due to the actual shrivelling of grains which had been damaged after development, but such loss is most noticeable on threshing the crop. The Thrips live and breed in the corn ears, leaving them only when the ripening grains become too hard for their weak sucking mouth parts to pierce. They hibernate during winter both in the adult and pupal stage, finding shelter in the soil, in the hollow stalks of the stubble, or amongst wild grasses. Once the corn is attacked the insect is beyond control, but measures recommended are harrowing and burning stubble in early spring, the burning of wild grasses about a field in autumn or early spring, and dressing the land with gas-lime or other insecticide—all methods of destroying the hibernating insects. Damage may also be avoided by early sowing of the spring oats, since the more mature the plants are the less they suffer.

Green-Flies or Aphides Attacking Potatoes. *F. V. Theobald, Pamphlet, S. E. Agricultural College, Wye, 1922.*—Various species of Aphides, Dolphin or Green-Fly, are known to attack the potato, each in its own way, and apart from the actual damage done they are said to be responsible for serious indirect injury because of the part they play in the transport of the virus of "Mosaic Disease" and "Leaf-Curl." It is essential that the various species should be clearly distinguished from each other, if progress is to be made in discovering the particular economic standing of each. The author describes, with figures, the species which occur in this country. Their attacks take place at different stages of the plant's growth. Three species have been found on sprouting potato seed, the most common being *Myzus persicae*, which occurs in great abundance on the vine; others are largely confined to the foliage and stem and to the roots. In Britain four common species are known to occur on potato foliage and tubers.

Sweet Clover as a Green Manure. *A. L. Whiting and T. E. Richmond, Illinois Agr. Expt. Stn. Bull.*—Sweet clover (*Melilotus alba*) should prove a promising source for supplying nitrogen to the chief farm crops. Certain characteristics give it a marked superiority over other crops as a green manure. The most important of these are:—

Adaptability to a wide range of climatic and soil conditions, if the soil is not acid and inoculation is assured; hardiness to cold and drought, resistance to disease and damage from weeds; vigorous growth; rapid decomposition whilst green; deep-rooting habit which renders impervious sub-soils more porous and of higher nutritive value.

A crop that possesses the combined capacity to grow rapidly in early spring and to decompose readily, makes an ideal green manure. Owing to its rapid growth clover conserves large amounts of soluble plant food, using it when the soil would otherwise suffer heavy losses. Similar to other legumes, when properly inoculated, the plant can utilise atmospheric nitrogen which it stores in its roots as reserve food material. The leaves are very tender and decay immediately after the crop is turned under green. The roots and stems decay more slowly; thus the different parts represent three sources of nitrogen which furnish three rates of nitrate production.

Hitherto considered as a weed, the sweet clover is now coming to be regarded as the best crop for soil improvement. As it will supply nitrogen at a low cost, it can be employed on a large scale.

The results furnish positive information concerning the value of sweet clover when used as a green manure, for adding to, conserving and making available for crop purposes the nitrogen of the soil. It is well known that, except for manure, the animal sources of nitrogen (dried blood, tanning residue, guano, etc.) are scarce and costly and therefore unsuitable for use on a large scale. This applies also to the use of nitrogenous fertilisers (sodium nitrate, sulphate of ammonia, ammonium phosphate and calcium cyanamide). On the other hand, the leguminous crops offer an exceptional advantage, and sweet clover in particular may in the future occupy a prominent position as a green manure.

The Sowing of Seeds and Scattering of Chemical Fertilisers Simultaneously. *A. Bandry, Comptes rendus des séances de l'Acad. d'Agric.*—Low crop yield is due less to the insufficiency of chemical fertilisers used than to their imperfect utilisation by the crops. It was decided to place within immediate reach of the young plants the mineral nutriment needed by them from the earliest stages of their growth. For fifteen consecutive years the author studied the application to extensive cultures of the simultaneous scattering of chemical fertiliser and seed grain in close parallel lines. The results obtained are as follows:—

(1) The maximum profit in practice from crops, both of cereals and pulse, has always been obtained by using quantities of chemical fertilisers varying from 300 to 400 kg. per ha.

(2) With more than 400 kg. of chemical fertiliser the value of the increase

in weight of the crops did not correspond with that of the increase in weight of the chemical fertilisers used.

(3) The yield per ha. of useful dry matter from the crops obtained by using 200 to 400 kg. of chemical fertilisers spread in lines has been at least equal and often superior to that obtained on the same soil by using 600 to 1000 kg. of the same fertilisers distributed in the usual way.

(4) Chemical fertilisers sown in lines at a depth of 2 to 3 cm. in close proximity to the seed have a beneficial effect on the young plants.

The author concludes that this method of utilisation of chemical fertilisers is so effective that it has become possible to reduce the quantities hitherto judged necessary to ensure the maximum practical profit from crops by 50 to 60 per cent.

The Relation between Organic Matter and the Assimilation of Mineral Phosphate. *F. C. Bauer*, *Soil Science.*—The use of mineral phosphate in conjunction with organic matter in a state of decomposition has been recommended, as it is considered that organic, nitric and carbonic acids present in the decomposing matter attack the phosphates and render them more available. This view, however, was not upheld by the laboratory experiments carried out for its confirmation. Although in practical farming, phosphates give the best results when associated with large quantities of organic substances, when chemical methods are used, it does not seem possible to prove that the phosphates themselves are actually rendered soluble to any appreciable extent, and various attempts have been made to explain this contradiction.

Truog was of opinion that phosphates when first precipitated in the soil in the form of very small particles are protected by a film of organic matter; Tottingham and Hoffman held the view that most of the phosphorus made soluble is utilised and organised by bacteria in such a way as to escape analysis. On the other hand many investigators have shown that plants possess to a greater or less degree the capacity of utilising insoluble phosphates. As a rule cereals are less capable than leguminosae, crucifers and buckwheat which can make great use of insoluble phosphate. This has been attributed to the secretion of organic and carbonic acids by the roots. Chirikov has shown that plants which possess this capacity assimilate lime readily and Truog considers that the quantity of lime contained in plants is related to the property of assimilating insoluble phosphate. It would be advisable to have recourse to these plants in order to render the insoluble phosphates available.

The author was unable to prove that organic matter in a state of decomposition had any effect in dissolving mineral phosphate.

In order to explain the way in which plants utilise mineral phosphate in the presence of organic matter in a state of decomposition, the author suggests two theories:—(1) The acids derived from the organic matter are able to dissolve the phosphate, or (2) the plants themselves are able by some means to effect its solution.

In order to study the power which plants may possess to dissolve mineral phosphate without the co-operation of organic matter the author carried out a series of cultures with fifteen plants in sand to which was added mineral phosphate or superphosphate, with or without lime and a further number of controls without any additions. The results have shown that plants are able to some extent to make direct use of basic phosphate, but in a less degree than soluble phosphate.

No connection has been recognised between the amount of phosphorus contained in plants grown in the presence of soluble or insoluble phosphate and the acidity of their sap or their different parts. Neither has it been possible to find any definite relation between the lime content of plants and their capacity to utilise insoluble phosphate.

The Influence of varying amounts of Sulphur in the Soil. *J. G. Lipman*, *A. L. Prince and A. W. Blair*, *Soil Science.*—The senior author has already called attention to the rapid oxidation of sulphur when intimately mixed with the soil, and with McLean and Lint has shown that the phosphoric acid of

rock phosphate is made available by the sulphuric acid thus formed. Sulphur was also suggested as a means of combating potato scab. It was recognised that the sulphur might have a detrimental effect on soil reactions, nitrate formation and crop yields. In order to obtain more definite information as to the action of sulphur, experiments were carried out in which sulphur was added at the following rates per acre: 200 lb., 500 lb., 1000 lb., 2000 lb., 4000 lb. Each plot had a control to which no sulphur was added. All plots received fertilisers containing 4 per cent. nitrogen, 10 per cent. phosphoric acid and 3 per cent. potash, at the rate of 600 lb. per acre. This was made from dried blood, acid phosphate and chloride of potash. Barley and soya-beans were grown in succession. The sulphur and fertiliser were broadcasted a few days before sowing the barley. Immediately after the harvest, at the end of July, the ground was disked and sown with soya-beans, harvested on 3rd October. Germination was fairly uniform, but as the season advanced there were signs that injury was being caused by the heavier applications of sulphur. The greatest yield was given by the plot to which was added sulphur at the rate of 200 lb. per acre; if this quantity was exceeded there was a decline in yield, until with 4000 lb. of sulphur almost all the plants were killed.

It was indicated that nitrification is not necessarily inhibited by a highly acid condition of the soil; a view which, although confirmed by other workers, is contrary to that hitherto held by most investigators.

The Function of Manganese Fertilisers. *H. Bocher.*—It may be said that to-day no farmer is ignorant of the action of manganese fertilisers, and also that among scientists few know the function and value of salts of manganese in agriculture. Nevertheless, everyone has heard of the manganese fertilisers placed on the market in 1910 by a commercial firm who advertised them widely. They were also well known after the long and minute researches made by M. Bertrand, Professor at the Sorbonne and Pasteur Institute, who proved the following facts:—

(1) Plants need manganese for the development of their cells;

(2) Manganese is a catalytic substance and a soil fertiliser.

M. Picard of Paris, in 1898, also pointed out to the Academy of Science (*Académie des Sciences*) the presence of manganese in the greater number of plants and proved its very important physiological function, especially at the beginning of plant life, at the moment of germination and early growth. M. Grandeau, Chief Inspector of Agronomical Stations, had also observed that manganese exists in all plants and that its presence seems necessary to plant growth. Further researches made by scientists of all countries have substantially confirmed these assertions.

Manganese acts in a variety of ways, directly or catalytically, as fertiliser, stimulant, antiseptic and anticryptogamic; it accelerates germination and maturation, increases the yield and improves the crop.

Experiments made everywhere, in Europe and Japan, have given results varying in importance but rarely negative. Difference of opinion arises not as to the actual principle of the function of manganese, which is incontestable, but as to the form in which it should be used. Many consider that oxides are ineffective; sulphate and chloride have given doubtful results, but carbonate and especially lime with manganese have been almost unanimously approved. The author next reviews all the researches which have been made in this matter up to the present, and hopes that further investigation will soon solve the remaining problems.

Bertrand has proved that the action of manganese is catalytic and influences the composition of various bodies without itself being modified, a suitable application of manganese stimulates the microfloral activity of the soil and ensures the better utilisation of the existing food material.

Boullanger has proved the great difference in the catalytic power of manganese according as the soil is rich in nitrogen, phosphoric acid and potash. In poor soil, chloride of manganese gave only a slightly increased yield of potatoes, but in rich soil, it showed an increase of 32 per cent. Canda, in Italy, also maintains that manganese has an indirect catalytic effect and

dissolves the previously existing fertilisers. In poor soil, its action may even be injurious. Kelley, on the contrary, maintains that the stimulating action of manganese is positive in poor clay-silicic soils, slight in rich soils and negative in acid soils.

Steyn and Burgers in Holland, observed that after the use of manganese, maize showed much greater development, the leaves became much larger and there was an increase in yield. Aso in Japan, Solomon in Italy and Dumont in France were also in favour of its use.

Investigations on the beneficial effect of manganese on plant life and especially on the acceleration of germination were made by the following: Garola, Crochectelle, Nottin, Bartmann, Loew, Boullanger, Voelker, Bauer and Molinari.

Experiments by Ray, Pradier and Bartmann prove that manganese accelerates maturation.

The increase in yield through manganese has been proved by numerous experiments. Thomassin obtained an increase of 20 to 35 per cent. in oats and 15 per cent. in beets; Boullanger an increase of 12 per cent. in oats with lime and manganese only, and of 40 to 48 per cent. by the addition of other fertilisers; Aso in Japan obtained an increase of 30 per cent. in the rice yield; and Bartmann's experiments on maize, cabbages and potatoes were equally conclusive, as well as those by Garda on flax, Leblanc on asparagus and Blanchard on onions.

Manganese not only increases the yield, but in many cases considerably improves the quality; this is especially the case with beets. Garola observed that manganese sulphate not only increases the weight of beets, but their sugar content also, by 50 per cent.; manganese chloride, which increases the weight still more, on the contrary increases the sugar content only by 25 per cent. Grégoire attributes to manganese an increase in sugar content and a corresponding decrease in weight, so that there is neither gain nor loss. Delorme and Boullanger observed that barley for malting did not increase in weight but improved in quality, the grain becoming larger, whiter and better nourished. J. M. Saulnier obtained very favourable results by using manganese salts.

As regards its antiseptic and anticryptogamic qualities Von Bauer observed that manganese causes chlorosis spots on diseased plants to disappear. Clausen Haide successfully used manganese against oat jaundice. Demolon, Sirot and Joret proved that slags used in agriculture contain from 4 to 5 per cent. of manganese to which they attribute some of the useful effects of basic slag which were previously thought to be due to phosphoric acid and lime.

To sum up, from all scientific research, and in addition from the results already obtained on farms, the importance of manganese becomes evident. It remains to be seen:—

(1) In what form manganese salts should be used.
(2) On what soils and crops they give the best effects.
(3) Whether they should be used alone, or mixed with other fertilisers.

The author concludes by insisting on the urgent necessity of further and numerous experiments to determine the exact value of this new fertiliser.

Experiments on the Use of Artificial Light in the Growth of Plants in Germany. *Hostermann, Verein Deutscher Ingenieure.*—The first experiments on the use of electric light for inducing the growth of plants were made in 1880 by Wilhelm Siemens, with a 1600 candle-power arc lamp; these experiments were next reproduced at Bromberg by means of arc lamps and mercury lamps with unsatisfactory results; on the other hand experiments made in England and Ireland in 1919 by Tjebhes and Uthoff induced an increased yield up to 50 per cent. In the buildings of the Experimental Station of plant physiology at Dahlem (Germany), experiments were made during the winter of 1921-22, to ascertain the influence of artificial light on the growth of plants in glass frames; in winter, in a heated place, the difference of growth of plants, compared with the summer, is determined not only by the temperature and by the manuring which may be the same at both seasons, but also by the duration of day light; in fact, it is the light absorbed by the chorophyll which furnishes the energy required for the reduction of carbonic

acid into carbon, from which carbohydrates are produced through assimilation. But it is not only daylight which exercises a beneficial action on the process of assimilation; this action can also be exercised by light coming from another source, provided that it is comprised in the category of wave lengths in the compass of which the colouring matters of the leaves have a power of absorption. The question is to select the light which will give the best return.

According to what can be deduced from researches on the physiology of plants, with a luminous intensity of about 1000 Lux, the assimilation may be considered as proportional to the illumination, while with a more intense light, assimilation is less and less accelerated and this is why artificial light was not used simultaneously with the winter light, but the day's light was prolonged from dusk by means of an electric current.

Over a plot 5 m. long by 1·50 m. broad were arranged five "Nitra" lamps of 200 watts, in such a way that the light could be diffused as uniformly as possible; the lamps were placed 0·70 m. from the edge of the plot, at a distance of 1·20 m. from each other at a height of 0·60 m. above the plot, and were furnished with Wiskott reflectors. The intensity of the illumination of the plants varied over different points of the surface of the plot from 300 to 900 Lux, and was exactly 900 Lux under the lamp and 300 at the edge of the plot. The daily consumption of electric power by the lamps, lighted for about six hours every day commencing at dusk, amounted to 4·8 kilowatt-hours for lighting a surface of 7 sq. m. Forced cultures were made on that surface: the preceding period of vegetation of some of them had already made it possible to have an idea of the principles assimilated; others, having just germinated had still to construct their vital elements. Close to the plot of illuminated plants was the control plot, with the same plants and separated from the former by a partition of white wood; this plot, except for light, received the same care as that of the illuminated plants.

Cabbage-lettuces, illuminated from mid-November, had after twelve days on an average about two and a half times as many fresh leaves as those not illuminated; moreover, the leaves of the former were larger and firmer, so that after eighteen days the plants had developed like lettuces sold at two marks each. Plants exposed only to daylight required from four to five weeks, or double the time to attain this degree of development; it would therefore be possible, in practice, to obtain in the same period of time two crops of lettuce instead of one. In eighteen days the consumption per lamp was 21·6 kilowatt-hours; the price at the time of the experiment being 1·20 mark per kilowatt-hour, it cost twenty-six marks for illuminating a surface of 1·2 sq. m. But as (with a doubled crop) 480 marks instead of 240 is drawn from a surface of 1·2 sq. m., there remains, at this price of electric current, a surplus gain of 214 marks per 1·2 sq. m.

To examine its subsequent growth, the lettuce was left in its place, since it did not flower but continued only to grow. However, this very probably, should not be attributed to lack of power of the electric light relative to solar light, but more especially to the richness of the artificial light in red rays, compared with daylight. The crop was gathered after seven weeks of prolonged illumination; a comparison was then made between the plants of the illuminated plot and those of the plot not illuminated: a superiority of weight of the former over the latter of 50 per cent. in the green state and 68 per cent. in the dried was found.

The effect was equally good on beans and vetches. *Lathyrus odoratus* grew much more vigorously under the influence of the illumination, and it flowered earlier and more abundantly. Strawberry plants illuminated yielded, as early as the middle of March, very sweet and scented fruit, while those not illuminated were four weeks later. The favourable effect of electric light in the prolongation of the short daylight from November to May, was very clearly shown on all greenhouse crops and especially on lilac which gave very fine inflorescences under this treatment, with more intense perfume and brighter colour. But certain data are lacking regarding:—(1) the most correct and suitable illumination for certain species of plants; (2) the duration of illumination; (3) the most favourable colours of the light; hence without exact

knowledge of the sources of light and of the physiological effects of the light, it is not yet possible to form a correct judgment.

The Insufficency of Lime and Phosphoric Acid in the Feeding of Animals. *R. Gouin, Revue de Zootechnie.*—It has been remarked that dry years are followed by an outbreak of more or less similar affections—rickets, gout, rheumatism, etc., having always a common cause, the insufficiency of mineral matter in the bones. Up to the present the mineral elements found in the animal organism are fairly numerous. We may suppose that, generally, the organism is well provided except with four of them—chlorine, sodium, calcium and phosphorus. It is easy to remedy the insufficiency of the first two. There remain the last two substances—Lime and phosphoric acid.

The direct assimilation of mineral phosphates was proved by Fillory. From researches made by Kohler, we may conclude that—(1) The mineral phosphates have been assimilated; (2) the assimilation of tricalcic phosphate has been greater than that of bicalcic phosphate; (3) the phosphates of degelatined or calcined bones are shown to be decidedly less. The author adds that bone meal may cause injury.

Some figures are quoted which have been obtained with full grown oxen to ascertain their daily requirements in mineral elements. Their examination shows that it is not enough to consider the deficient element, but that the proportions between the various mineral substances should also be considered.

The author draws the following practical conclusions:—As a general rule, for herbivorous animals receiving in their rations a sufficient quantity of good herbaceous forage, there is no need to trouble to supply a mineral supplement. With hay of the dry period, or obtained from acid meadows, or when straw largely predominates in the ration, phosphate of lime may suitably be added. It should also be added to the ration of cows in milk or in calf when they get less than 5 kg. of good forage per day. With calves it will always be wise to give phosphate of lime from the time they are weaned, or even earlier if they are brought up on skim milk. Pigs are given foods poorest in mineral salts. The good effects noticed when they feed on clover, lucerne and green forage, are largely due to better mineral nutrition and also to the vitamine furnished by growing plants.

The requirements for maintenance in phosphoric acid and lime are approximately proportional to the live weight, and are the same for all domestic species.

Growth in the pig requires from 1 to 2 gm. of phosphates of lime per 100 gm. of acquired weight. Taking digestibility into account, a pig weighing 50 kg., gaining daily 600 gm. should get from 40 to 50 gm. of precipitated phosphate; if this supplement is given in the form of bone meal the quantity should be doubled.

Limits of the Breeding Age in Thorougbred Mares. *Wood, Annales de Médicine Vétérinaire.*—In order to ascertain the age at which a thoroughbred mare ceases to reproduce, the author, who is a member of the Cambridge School of Agriculture, consulted the first volume of the General Stud Book, which covers a period of about one hundred years.

Out of 1216 mares, for which the dates of birth and of last foaling are exactly recorded, 709 (58·3 per cent.) reproduced at the age of eighteen years; 648 (53·05 per cent.) at nineteen years; 548 (45·07 per cent.) at twenty years; 457 (37·58 per cent.) at twenty-one years; 333 (27·38 per cent.) at twenty-two years; 248 (19·01 per cent.) at twenty-three years; 146 (12·01 per cent.) at twenty-four years: 85 (7 per cent.) at twenty-five years; 37 (3·06 per cent.) at twenty-six years; 17 (1·42 per cent.) at twenty-seven years; 7 (0·61 per cent.) at twenty-eight years; 4 (0·27 per cent.) at twenty-nine years; 2 (0·11 per cent.) at thirty years. One mare is recorded as having given birth to a foal at the age of thirty-three years.

From the above figures it would appear that the reproductive capacity of the mare lasts all her life. The fact that life does not last longer than the period of fertility is undoubtedly due to the state of the teeth, the wearing out

of which generally precedes the functional rest of the ovary. For this reason it is practically impossible to fix the epoch of the menopause for the mare.

The author has been able also to ascertain that in a total of eighty stallions death has taken place at the average age of 22·7 years.

The Different Thicknesses of the Skin in certain Breeds of Cattle. *J. G. Imboden, The Breeders' Gazette.*—Certain breeders consider that the lack of resistance shown by Shorthorns to both cold and wind is due to their thin skins, for Hereford and Aberdeen-Angus cattle, which have very thick hides, are even able to graze during a storm without experiencing any ill effects. The author resolved to test this statement, and collected data showing that the absolute hide yield is greatest in the case of the Herefords, the Aberdeen-Angus and Shorthorns following in decreasing order; the percentage is higher for bulls than for calves, and for one-year old calves than for two-year old animals.

Given equal quantities, the hide percentage of a thin calf exceeds that of a fattened calf of the same age. Climate and geographical position also have a considerable effect upon the hide yield, for cattle reared in southern regions where the heat is intense have thicker skins than those bred in the north, although the northern cattle have longer and more shaggy coats.

This difference is explained by breeders on the assumption that the thick skin of the southern cattle protects them from the rays of the sun and from insect attack, whereas a shaggy coat would be of little use. In the north and north-west, where there are fewer external parasites, the cattle do not need a thick hide, but require a heavy coat to enable them to defy the winter cold. The quality of the leather does not necessarily depend directly upon the general condition of the animal, and therefore a very good yield of hides can be obtained from cattle that have received but little attention. There is no practical difference between the commercial value of the hides of thin or of fattened calves.

Butter-Fat Percentage of Cow's Milk Increased for Two Days by Partial Milking. *W. M. Rigan and S. W. Mead, Jour. of Dairy Science.* In the supervision of advanced registry tests, it is required that cows be milked dry at the milking preceding the test period. This entails considerable loss of time and expense, and the question has arisen as to the necessity for the operation.

The author carried out some experiments with Holstein, Jersey and Ayrshire cows. The animals were milked dry twice daily for six days, on the seventh day only half the milk was drawn, and during the four subsequent milkings the cows were again milked dry.

Samples were taken at each milking and tested for butter-fat. It was found possible to increase the percentage of butter-fat in milk during a period of two days by leaving half the milk in the udder during the milking prior to the two-day period. Although the average increase in butter-fat was only 0·27 per cent. the data collected seem to show that it is possible to obtain an increase of over 0·5 per cent. by leaving a certain amount of milk in the udder, but if too much is left the contrary effect is produced. The highest fat percentage was not always reached at the milking following the partial milking; it was only attained in twelve out of the twenty-seven trials. As there was an average increase of only 0·0766 lb. of milk for the two days following the partial milking, the practice of leaving part of the milk in the udder could not be detected by a study of the cow's milk record.

The data collected in this experiment show that a preliminary milking is necessary as a measure for safe-guarding the accuracy of advanced registry testing.

The Treatment of Sterility of Non-Pathological Origin in Cows. *E. C. Daubler and M. F. Barnes, Jour. of Amer. Vet. Med. Assoc.*—The authors have treated cows which, although apparently normal in every other respect, showed no signs of heat, and succeeded in inducing the normal cycle

of heat periods and in rendering the animals fertile by giving them the ovaries or extracts from the ovaries of sows. Small pieces of the ovaries of healthy sows were administered, two at a time in a capsule which the cow easily swallowed, or a sterilised extract of sows' ovaries was prepared and injected, each cow receiving a subcutaneous injection of the extract of one or two ovaries. The latter method proved the more satisfactory. The ovarian extracts of commerce failed to produce the desired effect.

The Duration of the Contagious Period in Foot-and-Mouth Disease. *C. Lebail, Comptes rendus de l'Acad. des Sciences.*—The contagious period of foot-and-mouth disease is generally supposed to last for some weeks.

The Sanitary Authorities impose at least fifteen days quarantine after the recovery of the last case of this disease when it has broken out on a farm.

The author has found in his researches on cattle that any susceptible animal which is in contact with a diseased individual between the time of the initial rise of temperature and the rupture of the aphthae infallibly contracts the malady. If, however, the healthy animal is not introduced into the cattle shed until four days after the appearance of the first aphthic lesion which generally follows an attack of fever and salivation, the animal is not infected.

In the development of foot-and-mouth disease two periods should be distinguished; the first is the more dangerous, in that the only external symptom is a rise in temperature, but the second is the more distressing to the animals. When, however, salivation has taken place for four days they are no longer infectious, for the virus of foot-and-mouth disease dies on the spot.

The malady is spread by infected animals only during the periods of its incubation and inception which lasts a very short time. This explains the inefficiency of sanitary measures applied after the epizootic has developed to a certain extent. Even the most radical measure such as slaughtering the stock is no more effective than careful supervision and the seizure of the first centres of infection. At times when foot-and-mouth disease is epizootic, no animal, however healthy it may appear, should be introduced into a sound herd until it has been in quarantine.

Reindeer Imported to Canada. *T. A. Watson in Agr. Gazette, Canada. Vol. IX.*—In the northern territories of Canada, in the region corresponding to the tundra belt of the Old World, there is a vast area of unproductive country with very considerable potentialities. On several occasions the domesticated Reindeer of Northern Europe have been imported to North America with the idea that their successful establishment would be a first step towards the conversion to usefulness of the barren lands, the last successful importation being that to Alaska and the Yukon territory at the close of last century. Another attempt is now being made to naturalise domesticated Reindeer. Some 600 Norwegian Reindeer were recently landed on Baffin Island, and it is hoped to establish depôts at various centres throughout North Canada, where Reindeer may be reared in quantity for the butcher. It is also hoped that the mechanical exploitation of the region may be forwarded by the use that can be made of Reindeer as draught animals.

Poultry Feeding Methods Employed by Experiment Stations in the United States. *H. Atwood, National Poultry Jour.—Cornell (Ithaca N. Y.) Ration for Laying Hens.*—The scratch grain consists of a mixture of 200 lb. of cracked maize + 200 lb. wheat + 100 lb. oats. The grain is scattered in deep litter, in small quantities in the morning and more at night. The mash is composed of 200 lb. maize meal + 200 lb. wheat middlings (white) + 200 lb. meat scrap + 100 lb. wheat bran + 100 lb. ground heavy oats + 25 lb. oil meal + 4 lb. salt.

This mixture is fed dry in the open during the afternoon. The amount of feed is so regulated that about twice as much grain as mash is consumed. This ration is recommended for all breeds. For heavier breeds, however, the morning feed is limited so as to encourage exercise and a bigger consumption of mash. Green food, grit and oyster shell are also provided.

Ontario Agricultural College.—A small amount of whole grain is fed in the litter morning and evening, the quality depends on the price. Crushed oats is always supplied and sour milk or buttermilk forms the protein ration. Considerable care is taken that the supply of green food is abundant, mainly in the form of sprouted oats, then cabbage, rape, etc., Where no milk is available a mixture of four parts oats and three parts shorts, barley; maize or buckwheat meal is recommended, at the rate of 15 per cent. for the heavy breeds, and 20 per cent. for lighter breeds.

Storrs Experiment Station (*Connecticut*).—The scratch feed is composed of equal parts by weight of wheat and cracked maize ; the mash consists of equal parts by weight of wheat bran, maize meal, ground oats, flour middlings, beef and fish scrap. The dry mash is always available for the hens ; the principle feed of scratch grains is given about 4 p.m., but in winter a small amount is also given in the morning to induce exercise. Grit, oyster shell, charcoal and green stuff are also provided.

New Jersey State. -The mash is always available for the hens in hoppers, sufficiently large to permit one filling to last from one to two week at least. The following mixture is recommended : -

DRY MASH RATION.

Feed.	Quantity.	Protein.	Carbohydrates + fat × 2·25.
	Lb.		
Wheat bran . . .	200	24·2	90·6
Wheat middlings . .	200	25·6	121·4
Ground oats . . .	200	18·4	113·6
Maize meal . . .	100	7·9	76·4
Gluten meal . . .	100	25·8	65·6
Meat scrap . . .	100 to 200	66·2	35·1
Short cut alfalfa . .	100	11·0	42·3
Total . . .	1·000	179·1	545·0
Nutritive ratio 1 : 3·02.			

Every morning about 9 o'clock, in a deep litter, about 5 lb. of scratching ration is fed to each 100 hens, composed of equal parts of wheat and oats (protein 10·2 and 9·2 per cent. respectively ; carbohydrates + fat × 2·25 ; 73·0 and 56·8 per cent. ; nutritive ratio 1 : 6·6).

From 4 to 5 p.m., depending on the season, a ration is fed composed of 10 lb. to each 100 hens, fed in litter: 2 parts cracked maize + 1 part wheat + 1 part oats + 1 part buckwheat.

The proportions of protein are as follows, respectively, 15·8, 10·2, 9·2, 7·7 ; carbohydrates + fat × 2·25 ; 152·8, 73·0, 56·8, 53·3 ; nutritive ratio 1 : 7·8.

Wisconsin Agricultural Experiment Station.—The typical scratch feed consists of 2 parts cracked maize + 2 parts wheat + 1 part oats or barley. The mash consists of equal parts of ground maize, gluten feed, bran, middlings and meat scrap, fed at the rate of 1 lb. mash to 1 lb. scratch feed. A small amount is thrown in at night after the fowls have gone to roost, or in the morning before they go out. The fowls have easy access to the mash all the time, and a light mash moistened with skim milk or buttermilk when available is provided at noon. Cabbage, mangels and sprouted oats are given in winter and rape during the summer.

Maine Agricultural Experiment Station.—The following method has been found satisfactory. For each 100 hens, 4 qts. of whole maize are scattered in the litter in the morning, and at 10 a.m. they are given 2 qts. of wheat and 2 qts. of oats. Dry mash is always available, but it is stated that it is not advisable to feed pullets recently transferred to the laying houses on too rich a mash. During the first month (September) the mash consists of 3 parts

bran + 1 part middlings + 1 part gluten meal + 1 part meat scrap. The second month: 2 parts bran + 1 part maize meal + 1 part middlings + 1 part gluten meal + 1 part meat scrap.

For the third month, the same as for second month, with the addition of ½ part oil meal. During the following months the oil meal is alternately added and omitted. Sprouted oats are generally used as green stuff.

A fair degree of uniformity evidently exists among the various stations both as regards scratch feed scattered in the litter and the use of animal protein feeds (meat scrap, skim milk, etc.), and green stuff, grit and oyster shell. The following standardised ration may therefore be determined.

Scratch Feed.—5 parts cracked maize + 1 part wheat + 2 parts barley + 2 parts oats.

Mash.—Equal parts of bran, wheat, middlings, maize meal, gluten feed, ground oats and meat scrap.

Nutrient Requirements of Growing Chicks. *E. E. Musschl, D. A. Halbersleben and R. U. Sansted, Jour. of Agric. Research.*—Investigators in the field of nutrition have noted that chickens behave unlike rats or swine when limited to rations of one type, such as wheat or maize: this led to an enquiry into the values and deficiencies of the common feeding stuffs used for poultry and egg production.

The author carried out a large number of experiments, and proved that maize is not a satisfactory food on which to rear chicks.

The chicks chosen for the experiments were selected with great care; all were of the same age, viz., ten days; of equal vigour and development, and each group of nine was apparently uniform in all respects. The chicks were weighed individually every seven days and the figures obtained set out in graphs, the curves being typical of each group.

The ration was given in two parts; one as a coarse, the other as a fine feed; with the fine, or mash feeds, were mixed the supplementary ingredients, the effects of which the authors wished to study.

The results showed that maize is deficient in essential qualities, and is not suitable for the complete nutrition of growing chicks, which on this ration could not develop and ultimately died.

The additionof 5 per cent. of mineral substances, such as bone-ash, sulphur, salts of calcium, sodium and iron, were of assistance, and made possible a slow but continuous growth. The inclusion of maize gluten was ineffective.

The addition of 15 per cent. purified casein produced a marked improvement: it appeared that the casein supplied amino-acids, in which maize is deficient.

Supplementing the basal ration with other proteins, such as egg albumin and gelatin, lowered rather than raised the efficiency of the ration, and soya-bean meal was equally ineffective.

The addition of butter had no result: the fat contained substances which may have stimulated growth and so masked temporarily the lack of other essential accessories. There was a slight improvement in condition, followed by a loss of weight until the chicks died.

The addition of green foods brought about a decided improvement; green wheat was given in abundance, and eaten by the chicks to the extent of about 5 per cent., dry weight, of the whole ration. The helpful influence of green food may have been due to an improvement in the physical condition of the ration, and to a stimulating effect on the appetite.

Further experiments are now being carried out to ascertain the specific action of green foods.

With a ration formed of maize 65 parts, casein 15 parts, ash mixture 5 parts, starch 10 parts and unlimited green food, satisfactory growth to adult and egg-production stage was achieved, although the chickens were confined in a small pen under unfavourable conditions.

Studies on Beekeeping in the United States. *I.—G. S. Demuth; II.—E. F. Philips.*—I. THE CONTROL OF SWARMING.—The author discusses

the factors contributing to the tendency to swarm and to natural swarming and the best means of prevention. He then gives a detailed account of the most important measures of swarm prevention, viz.:—

(1) Careful selection of stock in breeding as some strains of bees have a stronger tendency to swarm than others.

(2) The use in the spring of brood-chambers and hives large enough to hold the maximum amount of brood without crowding.

(3) The use of good worker combs in the brood chamber to obviate a reduction in the available brood-rearing space.

(4) The arrangement of the brood combs so as to avoid placing barriers in the way of a free expansion of the brood nest during the spring.

(5) Providing extra space for the bees within the brood chamber by wider spacing of combs and a deep space below the frames.

(6) The use of large entrances during the swarming season, especially when the weather is hot, and in some cases, additional openings for ventilation.

(7) Protection of the hives from the direct rays of the sun by the use of shade-boards or double covers, or by painting the hives white, especially the cover.

(8) Preventing the building of barriers of sealed honey around the brood-nest, or breaking down such barriers if they exist.

(9) Inducing the bees to occupy supers as soon as the honey-flow permits during the first half of the season, or when the colony is rapidly increasing.

(10) Providing extra combs for the ripening of the nectar, so that the field bees can dispose of it as soon as they reach the hive, to prevent any stagnation of the activities of the colony.

(11) Removing some of the emerging brood to reduce the number of emerging bees within the brood-chamber, thus producing a better distribution of the bees throughout the hive.

(12) The destruction of the queen-cells, provided they have been but recently started. Frequently, however, when they have been destroyed, other cells are immediately formed.

Finally, as a remedy for swarming, the beekeeper relieves the congestion of bees within the brood-nest by creating conditions comparable either to the swarm, or to the parent colony in nature.

II. Diseases of Adult Bees.—The diseases so far known and of which the causes have been revealed by laboratory research are the following:—(1) Isle of Wight disease; (2) Nosema disease due to *Nosema apis*; (3) indirect toxic effects of spraying with insecticides containing arsenic salts.

The Isle of Wight disease, caused by *Acarapis* (*Tarsonemus woodi*) does not exist in the United States, according to specimens sent from the most different parts of the Union for examination by the author. In order to ascertain whether it could be introduced from Great Britain, where it appears to be widely spread the author had two infected hives sent out from England. When the first arrived all the bees, as well as the parasites, were dead; the second arrived with both bees and mites alive. Thus it is proved that the disease can easily be introduced by the importation of infected colonies.

The *Nosema* parasite already exists in the United States, and is even common there, but it seldom produces serious disease in adult bees in that country.

Electricity and Agriculture. *R. B. Matthews, Jour. of Royal Soc. of Arts.*—The problem of increasing the yield from the numerous small holdings in England and Wales has directed attention to the possibilities of use of electricity on the farm in districts where it is difficult to use gas and coal for machinery, etc.

The author points out the economic advantages to be derived from electric lighting for cow sheds, the improvement in cleanliness, reduction in waste of milk, cattle food, etc., by providing adequate light in habitually darkened buildings. In addition the electric motor can be readily utilised for machine work, for chopping cattle food, working churns, milk separators, etc. Such motors are easily handled and require a minimum of labour. The fact that

hay can be dried artificially by means of electrically driven fans gives the farmer more control over his crops and makes him more independent of the weather. Successful results with electric heating for the prevention of frost amongst stores of roots and vegetables have been reported, and also for drying fruits in bottling factories, etc. The use of electric heat has also already proved its value for incubation purposes, and has given an increased yield of eggs at a time of year when they are of the highest market value. There are undoubtedly great possibilities in its application to milk sterilisation and ensilage purposes.

Recent experiments on a practical scale have demonstrated that an extremely small amount of electrical power converted in a suitable apparatus to a very high tension and discharged from overhead wires strung across the fields has a remarkable effect upon most forms of vegetable life, increasing yield and in many cases advancing the period of harvest. Although it is at least possible that this effect may be rather in the nature of a stimulant than a food, and due to some effect upon the plant which improves its power of absorbing and assimilating nutriment from suitable soil, there is already sufficient evidence to justify careful and continued research in this direction.

The Production of large and small Farms in Sweden. *R. Höijer, Stockholm.*—The author divides the agricultural farms into four classes :—

1. Farms with a maximum of 2 hectares under cultivation.
2. „ 2 to 10 hectares under cultivation.
3. „ 10 to 50 „ „
4. „ over 55 „ „

He emphasises the great difficulty of determining the effect of a single factor—in this case, the size of the farm—upon the yield of the land. In this work he confines his attention to the quantitative production of the land, and deals with certain districts of Sweden that are similar in character.

In the case of each of these districts the author studies its importance from the agricultural standpoint, the climate, length of the growing season, annual rainfall, nature of the soil, percentage of the surface under cultivation, crops grown, state of the drainage, facilities for communication and percentage of the population engaged in agriculture. He also gives three graphic tables showing, for each class of farm, the standard of cultivation, the crop yield and the condition of stock-breeding.

The reader's attention is drawn to the fact that, as regards crop returns, the large farms are far superior to the smaller, although the cultivation intensity index of the large farms is lower. This is due to the fact that the figures taken do not represent the total intensity, but only the labour intensity. The latter is always higher in small farms, whereas the cultivation intensity is greater in large farms. If the total figures were available, there would probably be a change in favour of the large farms, and the intensity figures would correspond to the crop yield.

Conclusions.—The best size of farm depends upon the district; where agriculture is well developed large farms are more satisfactory, and from the point of view of the utilisation of the crops and their nutritive value, they are superior to small farms, but large farms are always more easily affected than medium, or small, holdings by changes in the general economic condition of the country.

On the other hand, in districts where the natural advantages are not great, small and average farms can always compete successfully with large farms, although their prosperity is only relative, for they are unable to adopt the methods of cultivation, or profit by the progress of technique to the same extent as similar holdings in more favoured regions, where larger farms are paramount.

Friesian Farmers' Co-operative Societies.—A statement has appeared in the press published by the Central Co-operative Book-keeping of the Friesian Farmers' Co-operative Societies showing the profits per concern in the last three years.

		Book-keeping Year. 1919–20.	1920–21.	1921–22.
Number of concerns controlled		218	276	382
Gross Profits per concern .	florins,	11,272	11,209	4876
Net Profits	„	6,829	6,578	25

Gross profits represent the profits before subtracting rent, interest and taxation.

Net profits include all profits derived by the farmers from free milk, meat, eggs, potatoes, etc., but not including free housing. If this included rent of a sum of 200 florins per annum, the average clear income for 1921–22 would be 225 florins, which proves that agriculture in Friesland was not a successful undertaking in the past year.

The Turnover of the Danish Co-operative Societies. *Berlingske Tidende.*—The total turnover of these Societies during 1921–22 is estimated at 1,248,000,000 kroners. Of this amount, 179·6 million kroners falls to the share of the so-called Consumers' Co-operative Societies; 134·7 million kroners to the Agricultural Purchasing Association, etc.; 926·6 million kroners to the Agricultural Producing and Selling Associations; and 7·2 million kroners to various Co-operative Societies.

Of the above, 174·6 million kroners were accounted for by the Faellesforening for Danmarks Brugsforeninger (the joint association of Denmark's Consumers' Associations; 101·5 million kroners by Fodder Stuff Associations; 535 million kroners by Co-operative Dairies; and 330 million kroners by Co-operative Slaughteries in respect of the trade in slaughtery products.

The turnover of the Co-operative Societies during the past ten years has been as follows:—

1912–13 . .	593·5 mill. krs.	1917–18 . .	874·7 mill. krs.
1913–14 . .	611·5 „	1918–19 . .	758·9 „
1914–15 . .	711·1 „	1919–20 . .	1165·3 „
1915–16 . .	890·1 „	1920–21 . .	1470·3 „
1916–17 . .	959·6 „	1921–22 . .	1248·1 „

Number of Pigs Slaughtered in Denmark. *Berlingske Tidende.*—Accounts from all the Co-operative Slaughteries in Denmark show that the production of pigs has greatly increased during the past year.

The total has now reached 1,880,000, while in 1921 only 1,400,000 swine were slaughtered, thus in 1922 there was an increase of about half a million.

In spite of this, the production of pork in Denmark at present is still below that of pre-war years, when it almost reached 2½ millions. However, from statements, one gathers that considerable additions of young pigs have been made, so that in all probability the current year will see a still greater increase than last.

OFFICIAL ORDERS AND CIRCULARS.

The following notice was issued recently by the Board:--

Agricultural Scholarships for Sons and Daughters of Agricultural Workmen and others.

THE Board of Agriculture for Scotland invite applications for the Scholarships described below from sons and daughters of agricultural workmen, or of other rural workers whose financial circumstances are comparable to those of agricultural workmen, or from persons who themselves are engaged in agricultural work.

Agricultural Scholarships.

Class I.—Short Course Allowances, not exceeding thirty, which will enable the holders to attend short courses of from four to ten weeks' duration in Agriculture, Horticulture, Dairying, Poultry-keeping, etc.

Class II.—Six Certificate Course Scholarships which will enable the holders to attend courses of instruction at the Agricultural Colleges during one winter session lasting about twenty weeks.

Class III.—Three Diploma Course Scholarships which will allow students to attend the courses of instruction for Diplomas awarded by the Agricultural Colleges. These courses as a rule require attendance at classes during three winter sessions of about twenty weeks each.

Class IV.—Three Degree Course Scholarships which will be tenable while students attend courses of instruction for Degrees in Agriculture or Veterinary Science during three academic years or thereby.

Forms of Application and full particulars regarding the Scholarship Scheme can be obtained from the Secretary, Board of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh.

Applications should be forwarded to the Education Authority for the area in which the applicant resides not later than 31st May 1923.

The Board issued the following circular letter during February to various institutions, associations and other bodies interested:

World's Dairy Congress, U.S.A., 1923.

SIR,—1. I am directed by the Board of Agriculture for Scotland to inform you that the United States of America will hold an international dairy meeting in October 1923, under the title of the World's Dairy Congress. The initiative was taken by the United States Government, through its Department of Agriculture, in getting the movement under way. The plan was taken up with enthusiasm by those interested in dairying and dairy products, and arising therefrom the World's Dairy Congress Association was formed. This organisation will conduct the Congress with the co-operation of the United States Department of Agriculture, and the International Dairy Federation will also co-operate.

World's Dairy Congress.

2. The Congress, which will be the first of its kind, will be a gathering together of representatives from many nations for the purpose of seeing and hearing about the latest advances made in the field of dairying. As the United States have attained a pre-eminent position in the sciences connected with dairying and in the commercial organisation of the industry, it is certain that the Congress will be of the utmost value to all participating countries, both from a scientific and commercial standpoint. Its purpose is to bring together the leading men of scientific and commercial experience for the consideration of all the larger problems involved, with a view to pooling the best information in existence concerning the importance of milk to the consumer, as well as the most effective and economic method of production, distribution and regulation. Those who attend the Congress will have a unique opportunity of studying on the spot the most approved modern methods of production, distribution, etc., of milk in the United States. For this purpose the programme of the Congress includes numbers of excursions

for the delegates to noted dairy districts and breeding establishments, to modern milk-handling and manufacturing centres and to prominent institutions of learning and research. Taking all facts into consideration it is believed that the expenses of delegates will be small compared with the value of the experiences which will be secured for the benefit of the bodies which they represent.

3. Four main groups of interests are concerned, viz., those connected with :—

(a) *Research and Education*, *e.g.*, teachers, investigators, engineers and other technical men interested in the solution of dairy problems.

(b) *Industry and Economics*, *e.g.*, men engaged in the business of production, manufacture, export, import, storage and distribution of dairy animals, products and equipment.

(c) *Regulation and Control*, *e.g.*, State, county, municipal and private officials concerned with standards, adulterations, sanitation and disease control.

(d) *National Health*, *e.g.*, public health and nutrition workers, philanthropists, welfare workers and students of the influence of diet on the health and vigour of the nation.

4. The National Dairy Association of the United States will hold its annual Exposition immediately following the Congress and in the same city. This Exposition brings together a thousand or more of the best bred cattle of the United States and Canada, while its mechanical exhibits occupy several hundred thousand square feet of floor space. The United States Government, the Universities and Agricultural Colleges have scientific and educational exhibits at the Exposition.

5. The Board of Agriculture for Scotland have been approached on the subject of the representation of Scotland at the Congress, and believing that full representation of Scottish dairying interests—educational, commercial and hygienic—will be to this country's advantage, they desire to do all in their power to further arrangements for such a representation. With this object in view, they have convened on two occasions meetings of representatives of the Scottish Board of Health, of public health bodies and of the various interests, educational and commercial, concerned with the dairying industry. At the second of these meetings on 16th instant, a small Executive Committee was appointed to co-operate with the Board in securing the representation of Scotland at the Congress in the two main directions :—

(*a*) Selecting a body of delegates to attend the Congress ;

(*b*) Arranging for suitable papers to be read at the Congress.

6. *Selection of Delegates.*—It is probable that apart from any action taken by this Committee, certain bodies will desire to send representatives to the Congress, and to pay their expenses. There may also be individuals prominently identified with the industry who may be sufficiently interested to attend the Congress at their own expense. It is desirable that the names of such representatives be submitted to the Board with a view to their approval as official delegates, in which capacity they will be entitled to certain privileges. It is equally desirable, however, that all other Councils, Associations and Companies who are concerned in any way in the milk industry should consider favourably the question of sending delegates, and for this purpose groups of bodies might conveniently consider the appointment of joint representatives. Although no binding assurance can be given, it is estimated that the ordinary expenses of a delegate will probably not exceed £100.

I am, therefore, instructed by the Board to enquire :—

(*a*) Whether your Council (Association, Company or Society) intend to send a representative to the Congress at their own, or his own, expense.

(*b*) Failing that, whether your Council (Association, Company or Society) will be prepared to co-operate with others to pay the expenses of a joint representative.

The Board trust that the necessary effort will be made to secure a Scottish representation, and they will be obliged if you will acquaint them as soon as possible of the action which will be taken in the matter.

It is very desirable that the names of all representatives should be submitted to the Board without delay with a view to their being placed on the official list of delegates, to whom special privileges will be accorded.

7. *Papers.*—The Board would be glad to receive suggestions as to the names (and addresses) of persons who might be invited to write papers for the Congress, with the subjects on which they would be qualified to write. Normally, papers will be written by persons who will be able to read them at the Congress, but the Board are prepared to consider the offer of papers by those who are unable to attend. Papers of general rather than local application are desired, and especially those dealing with *new achievements* in any branch of the dairy industry, and noteworthy advances in the sciences relative to dairying. Methods which have been found in any country to be of marked value in increasing production, lowering costs, stimulating consumption and improving national health should be reported.

8. Finally, I am to call attention to the fact that the matter is most urgent for two reasons :—(*a*) Papers should be in the hands of the United States authorities not later than 1st April next. Accordingly, as it is desirable that all papers should be in the Board's hands as early as possible before that date, I am to ask that you may be so good as to communicate to the Board, *not later than the second week of March*, the names of persons who have agreed to contribute papers ; (*b*) the selection of delegates must be made as soon as possible, in order that negotiations for special steamship rates may be opened and bookings fixed up.

I am therefore to ask that you will be good enough to arrange that this matter may have very early consideration, and notify me of the decision arrived at.

The following notice was recently issued to the press by the Board :—

Land Settlement.

Captain Elliot, M.P., on behalf of the Secretary for Scotland, recently made an announcement in the House of Commons with respect to the charges for buildings payable by small landholders who were settled by the Board of Agriculture for Scotland during the period between Martinmas 1918 and Martinmas 1922, and for whom buildings were erected by the Board during the period of high prices then prevailing. The announcement was to the effect that the Treasury had agreed in principle to an offer being made to the landholders concerned to have these payments reviewed by the Land Court.

We have been authorised to state that the Board of Agriculture are taking steps to carry out this decision, and that the Land Court have agreed to undertake the re-valuation, although it does not fall within their regular statutory duties. On settlements which are not situated on the Board's estates the re-valuation will apply to buildings only. On the Board's estates revision of fair rents will be carried out in connection with any re-valuation of the buildings.

The Board are preparing the applications to be made to the Court in consequence of the decision, and will communicate with the holders as soon as possible ; but it should be recognised that the completion of the applications by the Board will necessarily take time, and that the Court will then have no inconsiderable difficulty in overtaking this additional business.

The Board of Agriculture trust that the knowledge that this matter is in hand will go far to allay anxiety on the part of many small holders. The position of the holders will not be prejudiced by any delay in carrying out the re-valuation in any particular district.

STATISTICS.

PRICES of AGRICULTURAL PRODUCE and FEEDING STUFFS in December 1922, and January and February 1923.

AVERAGE PRICES OF LIVE STOCK IN SCOTLAND.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	December.			January.			February.		
	1st.	2nd.	3rd.	1st.	2nd.	3rd.	1st.	2nd	3rd.
FAT STOCK:—									
CATTLE—	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.
Aberdeen-Angus	76 6	70 0	44 2	73 10	68 0	44 6	70 7	65 1	44 10
Shorthorn	80 0	66 0	...	...	...	...	...	...	...
Galloway	67 2	60 2	...	65 10	58 0	...	62 2	54 9	..
Ayrshire	63 6	50 6	34 3	61 5	49 5	39 2	60 0	49 0	40 8
Cross-bred	70 11	63 4	41 5	69 0	61 11	42 6	66 4	59 6	42 7
Blue Grey	83 0	66 0	...	82 0	...	...	...	...	...
Highland	...	...	...	...	...		...	...	...
VEAL CALVES ..	per lb. d. 11½	per lb. d. 8¾	per lb. d. 6	per lb. d. 15½	per lb. d. 8½	per lb. d. 6¼	per lb. d. 16	per lb. d. 8¼	per lb. d. 5¾
SHEEP—	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds per lb. d.	Ewes per lb. d.
Cheviot ...	18	17¼	13½	18¼	17¾	13¾	19	17½	14½
Half-bred	17½	16½	12½	18	17	13	18½	17¼	13½
Blackface	17¾	16½	13½	17¼	16¾	13¾	18¼	16¾	14¼
Greyface	18½	17	12	18¾	17¼	12	19¼	17½	12¾
Down Crosses .	18¼	17½	...	18¼	17¼	13¾	18½	17½	...
PIGS—	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.
Bacon Pigs	15 2	13 8	10 0	15 0	13 7	10 1	14 3	12 11	9 2
Porkers	15 4	14 0	10 0	15 2	13 11	9 11	14 8	13 5	9 2

AVERAGE PRICES OF LIVE STOCK IN SCOTLAND—*continued.*

Description.	December. 1st.	December. 2nd.	December. 3rd.	January. 1st.	January. 2nd.	January. 3rd.	February. 1st.	February. 2nd.	February. 3rd.
STORE STOCK:–									
Store Cattle—	per head.	per head.	per head.	per head.	per head.	per head.	per head.	per head.	per head.
Aberdeen-Angus:	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Yearlings	20 3	16 7	12 18	19 10	16 1	13 8	18 0	14 16	9 0
Two year-olds ...	30 13	26 3	18 15	29 14	24 11	...	28 10	23 11	18 10
Shorthorn:									
Yearlings	...	...	...	...	...	...	...	...	...
Two-year-olds . .	...	...	...	...	...	...	...	...	...
Galloway:									
Yearlings	15 1	...	...	13 1	...	...	15 1	...	..
Two-year-olds ...	22 3	...	...	21 8	...	...	...	...	...
Ayrshire:									
Yearlings	...	...	...	..		...	...	...	
Two-year-olds ...	...	...	...	...	...	...	...	...	...
Cross-bred:									
Yearlings	17 2	14 3	10 6	16 11	14 7	8 15	17 0	14 7	12 3
Two-year-olds ...	26 10	22 6	18 10	27 0	21 10	18 10	26 16	21 17	18 9
Blue Grey:									
Yearlings	...	...	...	...	...	...	.	...	.
Two-year-olds ...	..	...	.	..	...	...	....	...	..
Highland:									
Yearlings	...	...	...	...	...	...	..	...	...
Two-year-olds ...	14 13	12 5		...	...	...	...	...	..
Three-year-olds ...	...	. .	...	...	...	...		. .	. .
Dairy Cows—									
Ayrshire:									
In Milk	37 5	27 3	14 0	36 19	25 4	13 16	37 5	22 17	10 7
Calvers	39 7	27 12	16 10	36 9	27 13	16 10	36 2	25 1	15 5
Shorthorn Crosses:									
In Milk	42 0	31 9	25 16	41 19	31 6	23 17	40 10	29 7	22 14
Calvers	41 6	30 1	21 10	39 9	28 11	20 0	39 17	28 11	19 8
Store Sheep—	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Cheviot Hoggs ...	71 0	37 0	...	59 4	45 5	...	63 5	48 1	42 3
Half-bred Hoggs ...	75 10	57 1	40 0	80 10	66 0	56 8	92 1	75 3	66 2
Blackface Hoggs ..	44 2	33 2	25 0	39 8	33 3	27 8	35 3	35 1	25 0
Greyface Hoggs ..	59 2	46 4	36 6	61 3	49 4	41 2	66 4	53 0	47 0
Down Cross ...	72 8	64 11	...	77 5	64 2	...	86 10	73 2	...
Store Pigs—									
(6 to 10 weeks old)	52 6	37 3	...	52 7	42 1	...	55 7	40 3	...

VERAGE PRICES OF DEAD MEAT AT DUNDEE, EDINBURGH, AND GLASGOW.

(*Compiled from Reports received from the Board's Market Reporters.*)

Description.	Quality.	December.			January.			February.		
		Dundee.	Edinburgh.	Glasgow.	Dundee.	Edinburgh	Glasgow.	Dundee.	Edinburgh.	Glasgow.
		per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
BEEF :—										
Home-fed—										
Bullock or Heifer ..	1	10⅝	10¾	13	10¾	11¼	12⅞	10¼	10¼	12⅜
	2	10	9	10⅛	10¼	9⅝	10¼	9⅝	9⅛	10¾
Bull	1	9	8⅜	8½	9⅛	8¾	8¾	8¾	9	8¾
	2	8	7⅝	6¾	8⅛	8⅛	7⅛	8	8⅛	7¾
Cow	1	7½	6¾	7½	8	7¼	8¼	8	7	8½
	2	6½	6	5¾	7	6½	6⅜	7	6⅛	6½
Irish—										
Bullock or Heifer ..	1	9½	...	9¼	10	...	10	...	.	10¼
	2	...	...	7⅞	...	...	8¾	. .	...	9
Bull	1	...	...	7	...	...	7⅝	...	...	8
	2	...	...	5¾	...	...	6¼	...	.	6½
United States & Canadian—										
Killed at Glasgow ...	1	...	..	...	...	...	10	...	...	10¼
	2	...	..		...	...	...	...	...	9⅞
,, Birkenhead	1	...	..	8½	..	...	9¾	...	...	9¼
	2	. .	...	8⅛	...	...	9½	...	...	8¾
Argentine Frozen—										
Hind Quarters ...	1	...	5¾	6	...	5⅞	5⅞	...	5¾	5½
Fore ,, ...	1	...	4¾	4⅜	...	5¼	4½	...	4⅝	4½
Argentine Chilled—										
Hind Quarters ...	1	...	7⅛	7	..	7⅜	7½	...	6¼	6½
	2	...	..	...	.	...	7	...	6⅛	6
Fore ,, ...	1	...	4⅞	4⅞	...	5⅜	5¼	...	4⅝	4⅝
	2	...	...	4⅜	...	.	4⅝	...	4¼	4⅛
Australian Frozen—										
Hind Quarters ...	1	...	...	5¾	...	5½	5½	...	...	5¼
	2	...	...	5½	...	...	5½	...	..	...
Fore ,, ...	1	...	...	4¼	...	4⅝	4½	..	...	...
	2	...	...	...	...	...	...	...	...	...
MUTTON :—										
Hoggs, Blackface ...	under 60 lb.	17	15½	17⅛	18⅜	16	17¼	18	15½	17⅞
	60 lb. and over.	16	14⅞	16⅛	17	15½	16¼	...	14⅞	16⅝
,, Cross	under 60 lb.	17	16⅛	17⅛	18⅜	16⅝	17¼	18	16⅜	17⅞
	60 lb. and over.	16	15⅜	16⅛	17	15⅝	15⅞	...	15⅛	16
Ewes, Cheviot ...	1	10⅞	10½	11⅝	12⅝	12½	13	13	12½	14⅛
	2	10½	...	10⅛	11½	...	11¾	12	...	13
,, Blackface ...	1	10⅞	...	11⅝	12⅝	...	12¼	13	...	13⅝
	2	10¼	...	10⅛	11½	...	10⅝	12	...	11⅝
,, Cross	1	9	9½	10⅛	10	11¼	10¼	9½	11⅜	11⅛
	2	8	...	9⅛	9	...	9⅜	9	...	10⅛
Argentine Frozen ...	1	...	8	8⅛	...	8⅜	8⅛	...	8⅝	8
	2	...	...	...	...	...	...	...	7⅝	...
Australian ,, ..	1	..	7¾	7¾	...	7⅞	7½	...	. .	7¼
	2	...	..	...	...	...	...	...	...	6½
New Zealand ,, ...	1	...	...	...	...	...	...	...	...	...
LAMB :—										
Home-fed	1	17	...	17⅝	18¼	...	17⅝	..	...	...
	2	...	...	15⅛	...	...	15⅝	...	...	...
New Zealand Frozen	1	...	12¼	12⅝	...	12⅞	12½	...	...	...
Australian ,, ..	1	...	...	11⅝	...	...	11½	...	...	11⅛
	2	...	...	...	..	...	...	...	...	9
Argentine ,, ...	1	...	10	...	..	10¼	...	...	10¼	...
	2	...	...	...	...	8	...	...	9	...
Dutch	1	...	...	...	...	15	...	...	...	...

(Compiled from Reports received from the Board's Market Reporters.)

Description.	Quality.	Dec. s.	Dec. d.	Jan. s.	Jan. d.	Feb. s.	Feb. d.
BUTTER:							
Irish Creamery... per cwt.	1	190	0	192	10	195	4
" " (Unsalted) "	1	198	6	199	2	200	0
Danish ... ... "	1	212	6	215	2	214	9
" (Unsalted) "	1	222	6	225	10	224	3
New Zealand ... ... "	1	196	6	205	0	211	0
CHEESE: Cheddar ... "	1	140	0	144	10	148	0
	2	136	0	141	7	146	0
Cheddar Loaf ... ... "	1	144	0	146	5	146	0
Dunlop ... ... "	1	130	0	135	7	140	6
	2	126	0	131	7	138	6
Canadian ... ... "	1	128	6	134	5	139	0
	2	...		...		...	
New Zealand ... ... "	1	..		139	0	140	6
New Zealand (White) "	1	...		...		141	0
	2	...		...		...	
BACON: Ayrshire (Rolled) "	1	178	9	177	7	167	9
Irish (Green) ... ... "	1	140	0	140	10	136	6
" (Dried or Smoked) "	1	160	0	156	0	152	6
" (Long Clear) ... "	1	156	6	153	2	142	3
Wiltshire (Green) ... "	1	140	0	140	10	136	6
" (Dried or Smoked) "	1	160	0	156	5	152	6
American, Long Clear Middles (Green) "	1	110	9	104	6	79	0
American, Short Clear Backs ... ... "	1	109	0	106	10	96	0
American Bellies ... "	1	86	0	86	0	86	0
" Sides ... "	1	109	0	100	10	78	6
	2	100	0	99	6	...	
" Cumberland Cut "	1	102	0	91	2	79	0
	2	...		...		...	
Canadian, Sides ... "	1	106	6	101	0	92	6
Danish, Sides ... "	1	129	0	121	2	109	0
HAMS: Irish (Smoked) "	1	175	0	172	0	190	0
	2	...		...		...	
American, Long Cut (Green) ... ... "	1	97	0	95	7	87	6

Description.	Quality.	Dec. s.	Dec. d.	Jan. s.	Jan. d.	Feb. s.	Feb. d.
HAMS *(continued)*:							
American, Short Cut per cwt.	1	98	0	97	7	90	0
	2	96	0	95	2	88	0
Canadian, Long Cut "	1	...		...		...	
EGGS: Country ... per doz.	1	3	7	3	2	2	5
	2	3	4	3	0	2	3
Irish ... ... per 120	1	27	2	27	7	18	5
	2	26	2	26	7	17	5
" (Cold Stored) "	1	20	4	21	5	...	
	2	18	8	...		...	
" (Duck) ... "	1	25	6	26	4	22	5
	2	...		...		...	
" (Pickled) ... "	1	16	6	18	6	...	
	2	...		...		...	
American ... ... "	1	18	3	20	5	...	
	2	17	6	...		...	
Argentine .. ... "	1	20	3	21	7	18	0
	2	19	0	20	4	...	
Canadian ... .. "	1	21	0	22	6	...	
	2	19	8	...		...	
Chinese ... ... "	1	...		16	6	13	7
	2	...		15	6	12	7
Danish ... ... "	1	28	0	28	3	20	0
	2	26	8	26	5	18	9
" (Pickled) ... "	1	18	0	...		...	
	2	...		...		...	
" (Stored) ... "	1	19	0	...		...	
Egyptian ... ... "	1	...		13	5	11	0
	2	...		12	3	10	5
Lithuanian ... "	1	...		...		...	
Polish ... ... "	1	16	9	18	0	...	
	2	16	6	...		...	
Pomeranian ... "	1	18	0	...		...	
Moroccan ... ... "	1	...		16	0	12	6
	2	...		15	0	...	
Italian ... ... "	1	...		26	0	16	0
	2	...		25	0	...	
" (Turkey) ... "	1	...		30	4	...	

AVERAGE PRICES OF POTATOES AT DUNDEE, EDINBURGH, AND GLASGOW.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Second Earlies.	Late Varieties. Red Soils. Lang-worthy.	Late Varieties. Red Soils. Other.	Late Varieties. Other Soils. Lang-worthy.	Late Varieties. Other Soils. Other.
		DECEMBER.				
		per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
Dundee	First ...	...	...	...	...	3 0 0
	Second ...	...	...	...	...	...
Edinburgh	First ...	...	8 10 0	5 10 0	8 10 0	3 7 0
	Second ...	...	...	...	...	...
Glasgow	First ...	...	8 0 0	5 10 0	...	3 9 3
	Second ...	...	...	...	...	...
		JANUARY.				
Dundee	First ...	...	...	...	...	3 0 0
	Second ...	...	...	...	...	...
Edinburgh	First ...	...	8 9 7	5 4 0	7 7 6	3 0 7
	Second ...	...	...	...	...	...
Glasgow	First ...	...	8 0 0	6 2 0	...	3 10 0
	Second ...	...	...	...	...	...
		FEBRUARY.				
Dundee	First ...	...	...	...	...	2 8 9
	Second ...	...	...	...	...	...
Edinburgh	First ...	...	8 10 0	5 0 0	8 0 0	2 16 0
	Second ...	...	...	...	...	...
Glasgow	First ...	...	8 5 0	5 3 9	6 15 0	2 18 3
	Second ...	...	...	...	...	...

AVERAGE PRICES OF ROOTS, HAY, STRAW, AND MOSS LITTER, AT DUNDEE, EDINBURGH, AND GLASGOW.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Roots: Carrots.	Roots: Yellow Turnips.	Roots: Swedes.	Hay: Rye Grass and Clover.	Hay: Timothy.	Straw: Wheat.	Straw: Barley.	Straw: Oat.	Moss Litter.
		per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton s. d.	per ton. s. d.	per ton. s d.
DECEMBER.										
† Dundee ...	1	...	21 6	30 0	135 0	...	90 0	...	90 0	...
	2	...	...	28 0	120 0	...	...	...	...	...
‡ Edinburgh	1	...	...	...	113 9	...	58 9	47 6	60 0	...
	2	...	...	...	73 9	...	50 0	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	28 6
	2	...	...	...	...	...	...	...	...	...
JANUARY.										
† Dundee ...	1	...	...	21 10	135 0	...	79 0	...	78 0	...
	2	...	...	18 0	116 0	...	70 10	...	70 10	...
‡ Edinburgh	1	...	...	20 0	111 0	...	53 0	42 6	54 0	...
	2	...	...	...	73 0	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	..	28 4
	2	...	...	...	...	...	...	...	...	...
FEBRUARY.										
† Dundee ...	1	...	...	17 6	135 0	...	73 9	60 8	71 11	...
	2	...	...	17 0	132 6	...	...	...	...	...
‡ Edinburgh	1	...	...	20 0	107 6	...	47 6	38 2	47 6	...
	2	...	...	...	82 6	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6

† Quotations at Dundee are for Hay and Straw baled and delivered.
‡ " Edinburgh are for Hay and Straw delivered loose in town.

Average Prices of Feeding Stuffs at Glasgow and Leith.

(*Compiled from Reports received from the Board's Market Reporters.*)

Description.	December.		January.		February.	
	Glasgow.	Leith.	Glasgow.	Leith.	Glasgow.	Leith.
	per ton. £ s. d.	per ton £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
Linseed Cake— Home	14 7 6	13 13 9	14 8 0	14 1 0	14 7 6	13 15 0
Foreign	13 15 0	13 5 0	13 15 0	13 10 0	...	...
Undecorticated Cotton Cake — Bombay (Home-manufactured)	8 0 0	7 5 0	8 2 0	7 8 0	8 1 3	7 3 9
Egyptian (Home-manufactured)	8 10 0	...	8 13 4	...	...	...
Coconut Cake ...	10 5 0	...	...	...	10 7 6	...
Groundnut Cake— Undecorticated ...	*10 0 0	10 12 6	*10 3 0	10 12 6	*10 6 8	10 12 6
Maize Germ Cake	11 2 6	...	11 2 6	...	11 2 6	...
Maize Germ Cake Meal	11 12 6	...	11 12 6	...	11 12 6	...
Bean Meal ...	13 7 6	13 10 0	13 0 0	13 8 0	13 0 0	13 0 0
Maize Meal ...	10 0 8	10 7 6	10 2 6	10 7 6	10 0 0	10 13 9
Locust Bean Meal	...	7 5 0	...	7 4 0	...	7 0 0
Rice Meal... ...	...	...	...	...	...	...
Maize Gluten Feed (Paisley)	9 10 0	...	9 10 0	...	9 11 3	...
Maize	†9 3 9	9 7 6	†9 2 6	9 7 7	†9 3 9	9 7 9
Oats, American ...	9 3 9	...	9 7 6	...	9 2 6	...
„ Home ...	9 12 6	9 5 0	9 13 6	9 5 0	9 9 5	9 5 0
Barley (Feeding) ...	9 5 0	10 0 0	9 9 6	9 17 0	9 7 6	9 5 0
Malt Culms ...	7 0 0	...	...	...	...	...
Distillery Mixed Grains Dried ...	9 0 0	8 16 3	9 0 0	9 0 0	8 18 9	9 3 4
„ Wet ...	...	1 15 0	...	1 15 0	...	1 15 0
Brewers' Grains— Dried	8 7 6	8 0 0	8 5 6	8 0 0	8 3 9	8 0 0
Wet	...	1 15 0	...	1 15 0	...	1 15 0
Distillery Malt Grains—Dried ...	8 15 0	...	8 8 0	...	8 13 9	...
Wheat— Middlings (Fine Thirds or Parings)	8 11 3	8 2 6	8 15 0	8 2 0	8 18 9	8 5 0
Sharps (Common Thirds)	7 7 6	7 10 8	7 7 0	7 5 0	8 0 0	7 5 0
Bran (Medium) ...	7 13 9	7 11 3	8 7 0	7 19 0	8 10 0	8 5 0
„ (Broad) ...	7 17 6	...	8 10 6	...	8 15 0	...
Feeding Treacle ...	5 10 0	...	5 10 0	5 10 0	5 10 0	5 10 0
Fish Meal... ...	15 0 0	14 15 0	15 6 0	14 10 0	15 13 4	14 15 8

* Oil and Albuminoids 40 to 42 per cent.
† American Corn.

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BASIC SLAG AND MINERAL PHOSPHATES ON HILL PASTURES.

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THE Border Counties Committee for the Development of Pastoral Lands recommended in 1918 to the Board of Agriculture for Scotland that there was need of experiments and demonstrations on the utility of mineral or rock phosphates as compared with basic slag for the improvement of land used entirely for grazing. The Board sanctioned a scheme for experimental plots at about twenty centres. These were distributed throughout the Borders district, the centres being selected after consultation with the local representatives on the committee. Two or three centres were allocated in each district, including Peeblesshire, Gala Water, Lauder, East Cheviot, Jed and the West Cheviot, Hawick, Liddesdale and Eskdale. The plan of the experiment at each centre was to top-dress half an acre with basic slag, and another half acre with rock phosphates, the two plots being separated by about half an acre of untreated herbage, which, with the surrounding untreated, served for a control. Preference was given to old pasture never ploughed or ploughed many years ago. Since stock concentrate on herbage treated with basic slag, the plots were laid down only in a few cases on open hill grazings, and were mainly in large enclosed fields, but these were not "improved grass," and the herbage was "natural pasture," except in one case (No. 6).

At the end of 1918 it was not easy to obtain any wide selection of grades of phosphatic manures, but Messrs J. & J. Cunningham, Limited, Leith, were able to supply basic slag with 24 per cent. phosphate of lime and North African mineral phosphates with 60 per cent. phosphate of lime. These were applied early in 1919 at the rate of 6 cwt. per half acre (12 cwt. per acre). The mineral phosphates contain two and a half times as much total phosphate of lime as the basic slag, but in the present state of knowledge as regards these phosphatic manures it is not possible to say how much of the phosphate is available for plant food. The plots were inspected by the writer, or reported on by the farmers from time to time, at least once a year. During the autumn of 1922 most of the plots were inspected with the assistance of members of the College county staff, and as the period since early in 1919, about three

and a half years, has allowed time for developments, it is considered that a report on results may now be given. The report also includes results of inspections or reports on other experiments on phosphatic top-dressings on grassland, including one laid down by the College in 1915, and others of more recent date since 1918.

The whole question of slags and phosphates has been discussed recently by G. S. Robertson.[1] His results were obtained from hay meadows in Essex. Other results published include those from the North of Scotland College of Agriculture (Bulletin 10) and from the University College of North Wales, 1913–15, both dealing with land under rotation. An important review of American results appeared in this *Journal* (July 1920, p. 357). From time to time reports have been published on the results of basic slag on hill pastures, but so far none of these have included a comprehensive comparison of slag and mineral phosphates. D. A. Gilchrist (*Journal of the Ministry of Agriculture*, December 1922) gives a brief account of an experiment with slag and phosphates applied in 1920–21; these are showing good results on moorland, but not where the herbage is coarse, with no clover plants, and with a thick mat of organic matter.

S. H. Collins and G. S. Robertson have divided rock or mineral phosphates into two groups—the softer North African rock phosphate with a woolly texture, and the harder North American and Island phosphates. Both groups are obtained by grinding natural rock deposits, and their utility increases with the fineness of grinding. The North African (used in our experiments) are more soluble by the citric acid test, and apparently contain more calcium carbonate than the harder American phosphates.

The plots were top-dressed in March or April 1919, which is generally regarded as late in the season for immediate utility. March of that year was unfavourable for growth in the south-eastern counties, though better further west. April was cold, and from May to July there was increasing drought which even in May had begun to retard the growth of new herbage on the lighter soils. By August hill pastures were generally bare, and most reports on the experiments in the autumn of 1919 state that little or no effect was evident from the top-dressings. In the moister districts, increase of clover and improved grazing were noted about Hawick, in Liddesdale and Eskdale, and a marked improvement was reported from Foulshiels (Yarrow).

The winter 1919–20 was one with much rain and snow, so that on the rougher matted pastures this was probably the period when most of the top-dressings were washed down towards the roots, and for some of the experiments in the drier districts the reports indicate that improvement began during this winter. The reports at the end of 1920 showed that changes were taking place at most of the centres. The long drought of 1921, from April to August, was a severe test of the experiments in the south-west

[1] G. S. Robertson, *Basic Slags and Rock Phosphates*. Cambridge University Press, 1922.

districts, but in July 1921 in the drier districts (*e.g.*, Lauder) increase of white clover and of greenness of the plots was recorded.

Comparison of Untreated and Basic Slag Plots.—Table I. gives some details of the various centres. They are arranged according to the definition of the basic slag plot as compared with the untreated in autumn 1922. The slag plots on the first eight farms could be distinguished from a distance, and the boundary was well defined. The next group (9-12) had the slag plots not clearly marked until on closer inspection, when the increase of white clover and the state of grazing were such as to allow the boundary to be followed from peg to peg. The last group (13-20) was not distinct, though closer inspection sometimes showed increase of clover and grazing.

The outstanding feature of Table I. is, that the better grazed and better defined plots were grazed by both cattle and sheep. Where "cattle" is placed first it means that the plots were regularly grazed with a number of cattle, as a rule during the summer only. Most of the plots were grazed by sheep alone or by "sheep and cattle," that is, the cattle were few (shepherd's cows), or only grazed irregularly. The effect of grazing is important, and will be considered later. There is no close connection between the kind of soil and the improvement resulting from phosphates. The soils varied considerably as indicated in Table I. As drought has played a considerable part during the period 1919 to 1922, it is desirable to distinguish between soils where the herbage soon becomes dry, and closer soils which retain moisture. In addition to field observations, the drying of the soils was observed in sods of turf in the laboratory, taken as representative samples of the herbage of the experimental plots. The soil description does not take account of the amount of the mat on the surface inch or two, a feature that varies considerably and is considered later. The variations amongst some of the better marked types of soil suggest that some other factor, such as state of grazing, is more important than the soil itself. Black moss soils include one of the better results (6) on land recently reclaimed from peat moss, and one of the worse (15), part of a flat marshy area never ploughed; another black top soil (16) formerly carried heather on a hill-top. Moisture favours improvement by slag and phosphates since the first seven (1-7) are deep soils in situations where moisture is available and is preserved; one is not a deep soil (8), but lies shallow over rock, and yet it gave a good result, probably because the rainfall is fairly high. The last three (18-20) form an interesting group of heavy deep soils with abundant moisture; the failure in these cases is not due to poverty of soil, but to the favouring of a strong growth of grasses, etc., which form high tough tussocks with a thick surface sod, and until this is grazed down or otherwise flattened out, white clover is entirely smothered. In other experiments where white clover has been sown into this strong benty or tussocky herbage, it has been

TABLE I.—Experiment Centres.

	Alt.	Exposure	Inclination	Soil	Cultivation	Stock
	Feet					
Slag plot well defined.						
1. West Loch, Peebles	1000	N.W.	Slope	Medium loam	Natural	Cattle and sheep
2. Davington, Eskdalemuir	700	E.	Slope-bottom	Light loam	Old plough (50 years)	" "
3. Broombaulks, Jed Water	900	...	...	Clay	...	" "
4. Letham, Jed Water	900	...	...	"	Old plough	" "
5. Foulshiels, Yarrow	700	S.W.	Slope	Medium to heavy	Old plough (from heather)	" "
6. Flatt, Liddesdale	400	...	Flat peat-moss	Black	Ploughed 1912	" "
7. Lauder Parks, Lauder	700	E.	Slope-bottom	Heavy loam	Natural, heathery	Sheep
8. Drochil, Peebles	950	E.	Slope	Medium loam[1]	Old plough	"
Slag plot visible, not well defined.						
9. Brownshall, Lauder	700	...	Flat, benty marsh	Red sandy loam	Old plough	Sheep and cattle
10. Scabcleuch, Ettrick	900	S.E.	Slope	Medium loam	"	Sheep and horse
11. Kirkton, Rule Water	850	S.E.	Ridge-top	Heavy	...	Sheep and cattle
12. Saughtree, Liddesdale	700	E.	Slope-bottom	Heavy, moist	Natural	" "
Slag plot, badly defined.						
13. Halltree, Gala Water	900	N.E.	Slope	Medium loam	Old plough	Sheep (lambing)
14. Cliftoncote, Bowmont Water	750	...	"	"	"	" "
15. Hindside, Lauder	750	...	Flat	Black, over clay	Natural	Sheep
16. Hangingshaw, Gala Water	1200	...	Hill-top	Black, over stoney[1]	Old plough (from heather)	"
17. Whitfield, Hawick	900	N.	Slope	Medium loam[1]	Natural	Sheep and cattle
18. Shaws, Liddesdale	550	W.	"	Heavy, moist	Natural (drained)	Sheep
19. Menzion, Tweedsmuir	1000	W.	Alluvial	"	Natural	Sheep and cows
20. Henderland, Yarrow	800	...	Alluvial, flat	"	Old plough	Cattle and sheep

[1] Shallow soil over rock.

observed that the clover makes little progress, except in places where the grasses are shorter, such as along a sheep track.

Plots Top-Dressed with Mineral Phosphates—The general results of a comparison of the mineral phosphates plot with the neighbouring basic slag one are briefly :—

(*a*) Ground rock phosphates act more slowly during the first year.

(*b*) They encourage the growth of grasses, so that the plots, even after three years, generally show an herbage rougher than the slag plots, but not so rough as the untreated.

(*c*) They encourage white clover, but its growth is retarded by roughness of the grass, so that it does not form a close sward except where the grasses are short.

(*d*) They encourage grazing, as is seen by examining the grass tufts, but the grass shoots soon elongate, and the plots are more grassy than the slag plots.

(*e*) There is some evidence that the top-dressing with rock phosphates lasts longer than that with basic slag.

The reports for 1919 and 1920 are almost unanimous that the mineral phosphates plot was longer in showing improvement than its basic slag neighbour, but two reporters (6 and 10) state that in the autumn of 1920 the phosphates plot was slightly the better.

The roughness of the mineral phosphates plot was observed at almost every centre from 1920 onwards. This roughness is due to the grass shoots being taller and stronger than on the slag plot. At first it might be thought that there had been no grazing, but in the herbage analysis it was found in 1922 that the grass treated with mineral phosphates had been considerably grazed. Ungrazed grass plants from untreated herbage show a few spindly shoots arising from the crown, and many of these flower where there has been no grazing. Plants from the mineral phosphates plot also show some long shoots, but at the crown there is a close tuft of shoots which have arisen as "tillers" when the main shoot has been grazed off. This enlarged close-tufted crown is a feature of grazed grass, and is a better test of grazing than a superficial observation of the length of shoot. In most cases the mineral phosphates plot showed few flowering grass shoots (in autumn), whereas on the untreated part flowering shoots were more abundant.

The botanical analysis of turfs collected from the various centres included a count of the grass shoots. As is to be expected from the rougher appearance of almost all the samples of herbage from the mineral phosphates plot, the weight of herbage exceeded that of the slag plots, but in many cases it also exceeded that of the rougher untreated herbage which had been little grazed. The number of grass shoots (Table II.) obtained by counting was generally greater from the phosphates plot than from the untreated. This increase of grass after slag and mineral phosphates has been observed by G. S. Robertson,

who has evidence that it is not altogether due to the nitrogen accumulated by clovers. In our case the increase of grass after mineral phosphates has been more than after slag, but along with this has to be considered the rougher state of the herbage and the smaller amount of white clover. There is a possibility, which requires further observation, that the increased grass production after mineral phosphates may be an advantage, especially where cattle are grazed. With basic slag treatment there is often seen a close sward of clover mixed with fine grass shoots, but the coarser herbage of the mineral phosphates may be more useful, and it will stand better through frost or drought.

Botanical Analysis of Herbage.—Distance and inaccessibility of the centres made any detailed analysis difficult and costly. The methods used during the past eight years on the permanent pastures at Dreghorn farm take so much time that the phosphates centres would have taken one or two days each of good weather. Two methods were adopted to ascertain the changes in herbage. On each visit careful notes were taken, including amount of white clover or other leguminous plants, the state of the various grasses, and in particular the state of grazing of the plots. A more accurate analysis was attempted from typical turfs collected in the autumn of 1922, and a few of the more complete are given in Table II. An indoor analysis of representative turfs has considerable advantages, especially in identifying the smaller grasses. The fault of the method is that one or two samples may not fairly represent the plot from which they are taken. On the whole, however, the information from selected turfs was found to agree well with the notes taken in the field, for example, as to amount of clover and state of grazing. The grazing season for any one set of plots has an important effect on the herbage. The plots grazed in early summer, about lambing time, are eaten down and are improved in appearance then, but where saved for winter grazing these plots tend to show up rough on autumn inspections (*e.g.*, 13 and 14, Table I.). The wet summers or autumns since 1919 also make the plots rougher in autumn, and tend to conceal the white clover and moss. Table II. gives a detailed analysis of seven farms from autumn samples. A portion of the sod was teased out, and the grasses, etc., identified and counted (Figs. 1 and 2). Each grass shoot is counted as one, and for white clover each branch, though these vary considerably from long straggling shoots in rough herbage to short branches in clover swards. The weeds are not detailed except Field Rush (*Luzula campestris*) and Plantain or Ribgrass (*Plantago lanceolata*), which are tufted spreading plants frequently present in untreated herbage. The number of shoots has been multiplied up to give the number per square foot of turf. In calculating the percentages an attempt is made to show the surface covered. A grass shoot is elongated, narrow and occupies little space, whereas a branch of white clover with its leaves covers more surface, and the same applies to most of the weeds present.

TABLE II.—BOTANICAL ANALYSIS. (Explanations, *see* text.)

	West Loch			Davington			Broombaulks			Letham			Flatt			Lauder		Scab-cleuch	
	O.	M.P.	Slag.	O.	M.P.	Slag.	O.	M.P.	Slag.	O.	M.P.	Slag.	O.	M.P.	Slag.	O.	Slag.	O.	M.P.
GRASSES—																			
Bent (Agrostis) .	480	720	600	1440	...	648	...	...	...	...	...	...	2340	1152	1540	2690	1056	...	...
Sheep's Fescue .	744	1440	2040	1080	...	1980	...	...	...	...	...	...	720	252	1290	770	624	...	...
Sweet Vernal . .	24	...	84	216	...	...	...	...	...	...	...	...	...	...	...	...	290	...	...
Yorks. Fog (Holcus)	...	...	...	36	...	...	...	...	...	...	...	...	...	432	170	...	...	...	...
Crested Dog's-tail .	...	...	...	...	...	216	...	...	...	...	...	...	...	792	...	...	120	...	...
Meadow (Poa) .	...	160	...	...	...	...	...	...	...	...	...	...	...		...	(40)	...	...	...
Total Grasses	1248	2320	2724	2772	4440	2844	2880	4064	3200	4600	5250	4000	3060	2628	3000	3500	2090	1920	3840
White Clover . .	336	480	1080	24	240	108	108	80	672	0	100	220	0	144	924	16	360	72	72
WEEDS—																			
Field Rush . .	84	128	12	180	...	...	...	...	32	...	...	...	288	...	...	16	72	...	...
Plantain . . .	60	...	24	108	...	...	108	...	...	...	...	...	...	...	...	128	...	144	24
Miscellaneous .	360	560	420	216	...	144	216	80	32	...	...	...	396	36	588	264	...	...	456
Total Weeds	504	688	456	504	160	144	324	80	64	20	0	80	684	36	588	408	72	144	480
PERCENTAGE—																			
Grasses . . .	42	50	47	73	85	85	77	93	68	99	96	87	82	88	50	89	71	82	78
Clover . . .	24	21	37	1	9	6	6	4	29	0	4	10	0	10	31	1	24	6	3
Other Plants . .	34	29	16	26	6	9	17	3	3	1	0	3	18	2	19	10	5	12	19
Moss (grams, dry) .	19	16	5	25	18	58	6	8	3	9	7	9	...	...	...	...	...	24	5

Before making up the percentages the number of shoots or branches of white clover and weeds has been multiplied by two, thus making the percentage a rough but useful index of space occupied by each group of plants. The variation in the amount of mosses was obtained by weighing the air-dry moss shoots obtained from each analysis, and multiplying this up to grams per square foot; about 28 grams equals 1 oz., so that some of the plots have up to 2 oz. per square foot of dry moss.

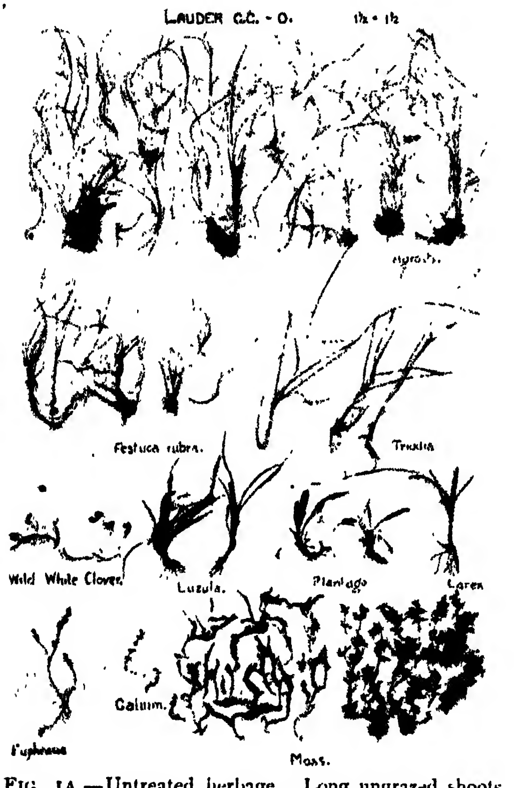

FIG. 1A.—Untreated herbage. Long ungrazed shoots, scarcity of clover, abundance of moss. (Sample, smaller than B).

The grasses show a striking uniformity from all the plots. Two grasses predominate, viz., Bent (*Agrostis vulgaris* and *Ag. alba*) and Red Sheep's Fescue (*Festuca rubra*), with occasional occurrence of the finer true *Festuca ovina*. As a rule, Bent is the more abundant on untreated herbage, and its broader leaves contribute to the rougher appearance of this herbage. Red Fescue has generally increased on the treated plots, especially with basic slag, and the finer bristle leaves of this grass bring about the finer appearance of the grass in treated plots. This result is due to grazing. Both grasses tiller freely after being grazed, but the Fescue does so much more abundantly than Bent, and the new shoots are slender, with finer and shorter leaves than ungrazed Red Fescue. The third abundant grass is Sweet Vernal (*Anthoxanthum odoratum*). These three, Bent, Red Fescue and Sweet Vernal are grasses which assist in the formation of the mat or sod on the surface of old grassland, and they thrive in this mat when other more useful grasses die out. They have long runners, and so keep up connection through the surface mat between the roots earthed in soil and the leaves in the air; in the mat itself they form numerous rootlets that absorb rain water. Yorkshire fog or pluff grass (*Holcus*),

another mat-forming grass, was abundant in two places only (Flatt and Hindside), but after application of the top-dressings it rapidly disappeared. Crested Dogstail (*Cynosurus*) and the Meadow grasses (*Poa*) flourish where there is little or no mat, and their presence indicates a better type of untreated grassland; they have been encouraged by the phosphatic dressings. Blue moor grass (*Molinia*) was abundant at three centres (18, 19, 20) on wet peaty soils, where it assisted in forming the strong rough tussocks that caused the failures at these centres. Mat grass (*Nardus*) was abundant at the same three centres, and present to some extent at Lauder Parks, Brownshall and Whitfield. Tussock grass (*Aira caespitosa*), a moisture-preferring grass with strong tussocks, was found in some quantity at Shaws, Kirkton and Hindside. Another moor grass (*Triodia decumbens*), found in small amount at Lauder Parks, may be present on other plots, as it is not uncommon on hill pastures (Fig. 1A).

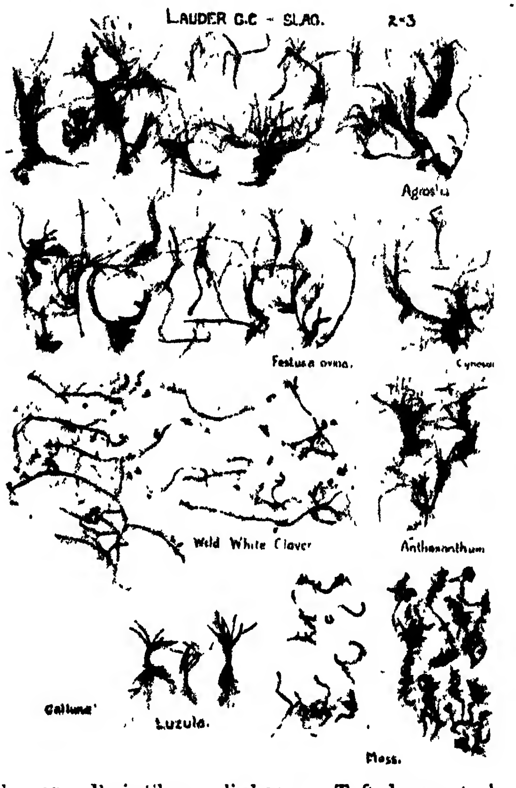

FIG. 1B.—Basic Slag applied 1919. Tufted grass stools, result of grazing. Increase of clover, reduction of "weeds" and moss. ("*Festuca ovina*" includes *F. rubra*).

White Clover.—Increase of white clover and other leguminous plants has been frequently recorded in successful experiments with phosphatic top-dressings. The usual recommendation is not to apply basic slag unless the herbage shows traces of clover plants, and on the whole this is a safe rule, but the future progress of the clover depends largely on suitable grazing. The well-defined plots (Table I.) showed a marked increase of clover with one exception (Davington), where an increase is not well marked in the sods analysed in 1922, although the herbage here had some white clover before treatment, and in 1919 some increase was noted, which does not appear to have continued. The less defined plots (Table I.) were generally deficient in clover, although

increase could be noted in most cases. The results indicate three factors adverse to the increase of clover :—(*a*) insufficient grazing of rough herbage; (*b*) presence of a thick fibrous turf; (*c*) soil defects.

The first two go together, because a thick mat of surface fibre is largely the result of insufficient grazing. In the worse defined plots the rough ungrazed herbage suppressed the clover. Thus in three cases—Shaws, Whitfield and Hindside—there was distinct increase of clover in 1920, both on slag and phosphates plots, but the clover shoots were long, thin and straggling through the rough grass. It was evident from what was seen on sheep tracks or places where the grasses were kept down, that the clover could form mats of short shoots with many leaves, as on certain patches of Hindside and Brownshall.

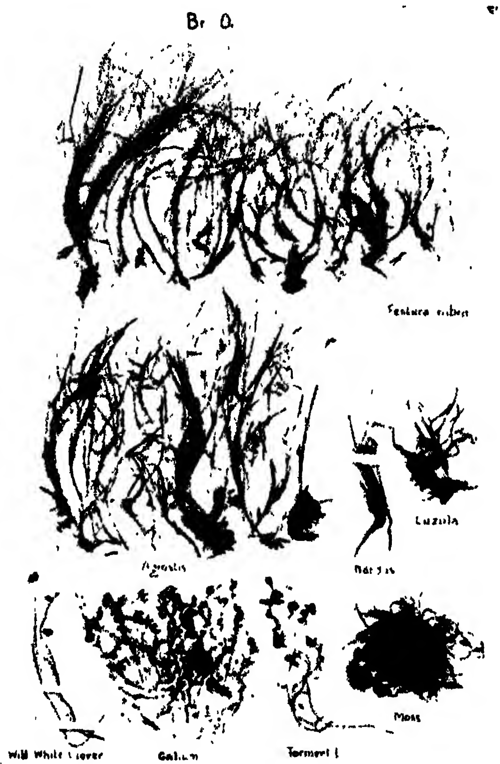

FIG. 2A.—Untreated herbage, Long ungrazed grass shoots and Bedstraw (*Galium*); long straggling shoots of white clover.

Some cases of "failure" of white clover are apparently due to drought, *e.g.*, Scabcleuch and Hangingshaw. The former is a steep south-exposed hill, and when seen in September 1919 it was just recovering from severe drought; records for 1920 showed some increase of clover, but 1921, another dry year, seems to have checked it. At Hangingshaw on a high hill-top ploughed out from heather about fifty years ago, the slag was applied to the poorer herbage and clover increased little, except on a part with deeper soil; the phosphates plot lying nearer a wall showed considerable improvement and a considerable increase of clover, as the result of better soil moisture during the drought seasons. While drying turfs in the laboratory it was noted that the white clover withers much sooner than the grasses, especially where the surface fibrous mat is open, whereas it lasts longer where the

surface is more consolidated. The failure of white clover is again referred to under "grazing."

Other Plants.—Table II. shows the prevalence of Field Rush (*Luzula campestris*) and Ribgrass plantain (*Plantago lanceolata*) in the untreated herbage. Amongst other plants, the slender leafy shoots of Heath Bedstraw (*Galium saxatile*) and the broader leaves of Tormentil (*Potentilla tormentilla*) were frequent on heathy herbage. The remaining "weeds" varied from farm to farm, but need not be detailed as they were not abundant. Reference to Table II. shows that both in number of shoots per square foot and in percentage, the phosphatic dressings have reduced the amount of "weeds," especially in the better defined (*i.e.*, better grazed) plots. This reduction is more the result of better grazing than any direct effect of the phosphates, and it will be seen that in several cases there is a larger reduction on the close-grazed slag plots than on the rougher mineral phosphate plots. The same reduction is seen in the amount of moss ("fog") so common in grassland. This confirms earlier observations already given in this *Journal* (Vol. V., No. 1, January 1922, p. 48). Where white clover has distinctly increased (West Loch and Broombaulks) the amount of moss is decreased, but with less increase of clover (Davington and Halltree) the moss still persists. At Scabcleuch the improved state of grazing on the phosphates plot, without increase of clover, has reduced the moss.

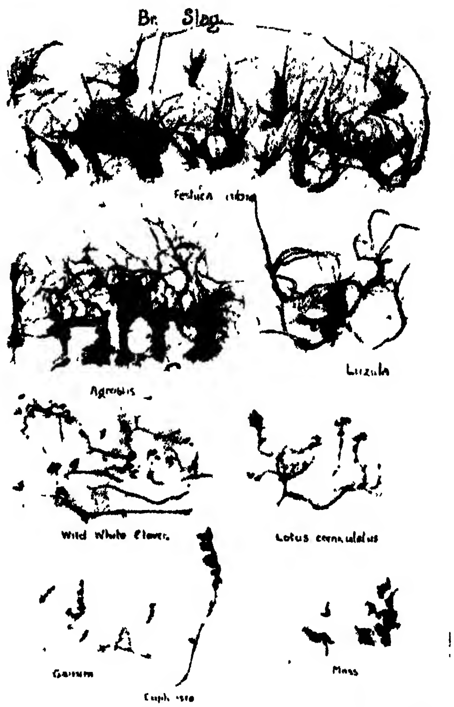

FIG. 2B.—Basic slag applied 1919. Close grazed grass, increase of clover and bird's foot trefoil, decrease of "weeds" and moss.

Grazing.—It has already been emphasised that grazing has much to do with improvement after phosphatic manures. It is an old observation, confirmed by many shepherds, that sheep gather on basic slag plots almost as soon as it is applied. This cannot be due to increase of clover, for there has been no time, and the attraction seems comparable to that where salt has been put on pastures. There is evidence that with basic slag the lime present "sweetens the bite." In our experiments it was not observed that

the mineral phosphates had the same attraction for sheep when recently applied. The early gathering of sheep on herbage after basic slag leads to increased grazing, and increase of droppings, and the brighter green of treated plots is due to the removal of the dusky older grass and the exposure of fresh green shoots. The first effects of grazing are seen along tracks or hollows, of finer herbage among the coarser. Here, white clover can generally be first detected, and as grazing proceeds the margins of the rougher tufts are eaten into more and more. Where improvement is complete, these tufts are entirely obliterated. This result was more frequently seen after basic slag than after mineral phosphates.

Increase of white clover increases the grazing of the grasses by stock. This has been examined during the botanical analysis and holds good. Where, however, clover has not increased much, there is also evidence of the grasses being grazed more or less. Phosphatic manures are regarded as mainly beneficial to the white clover, but as already pointed out they are favourable to the growth of the grasses.

Consideration of the observations on grazing has led to the following grouping of the experiments, which shows the condition of the untreated herbage and the result of treatment. The grouping suggests that undergrazing is against improvement, and it seems probable that a heavier stocking would accelerate the action of phosphatic top-dressings, though economic conditions and management of hill pastures have to be considered before making criticisms.

A. Untreated herbage distinctly undergrazed, rough and flowering—eight centres—Nos. 15 to 20 (Table I.), little or no improvement; Lauder Parks and Brownshall, both marked improvement with slag, less with phosphates. In the first six (15 to 20) the plots are on large pastures where the stock have a wide range and are not concentrated on any part. At each of these centres the surface fibrous mat is open, about 1 to 2 inches thick in three cases (15, 16 and 17), and deeper and more matted in the other three (18, 19 and 20). This thick mat is well known to be adverse to top-dressings. The successes of this group are Lauder Park and Brownshall, and this is to some extent due to local conditions. The Lauder plots adjoin the golf course and carry a heathery unpalatable herbage, but since the application of the phosphatic manures the sheep have concentrated more in this corner when driven off during play, and the increased grazing has hastened an improvement almost unexpected by Dr Shirra Gibb when he selected the ground for experiment (Figs. 1A and 1B). The herbage at Hangingshaw (No. 16) is much the same type, but the stock have a wide range and the hill is not suited for bad weather, yet on one part adjoining a wall there has been a marked improvement, probably due to greater grazing in better shelter. At Brownshall (No. 9) the plots were laid down near a gate, and partly on drier soil on a slight rise, which has tended to increased grazing on this part (compare Figs. 2A and 2B).

B. Untreated herbage partially grazed but distinctly rough in autumn—five centres—Flatt and Drochil, marked improvement with slag, less marked with mineral phosphates; Kirkton some improvement with slag and phosphates; Halltree and Cliftoncote, little improvement, at least in autumn. Examination of these plots showed that although at first sight the untreated herbage looked rough, there had been considerable grazing at some time during the year. At Flatt the field, cultivated after breaking from peat moss, was laid down to grass, part in 1913, part in 1917, but the grass came badly and on the first inspection in 1918 it was a mass of pluff grass (*Holcus*) and bent (*Agrostis*); the parts top-dressed soon attracted grazing stock, and the number of animals was increased, so that by the end of 1920 Mr Riddell reported considerable improvement, including the mineral phosphates plot, and a later inspection showed great reduction of the pluff grass and increase of clover and other grasses all over the field, but there was also a distinct increase in rushes (*Juncus*); the whole field has since been slagged and is now well covered with clover and useful herbage, but the rushes seem still to be increasing. At Drochil the shepherd reported considerable improvement of the top-dressed plots in 1920 and 1921, but when inspected in 1922 there was considerable roughness in places, especially on the phosphates plot, and clover was not so abundant as it had been earlier. At Kirkton, a farm where basic slag has been largely used, with excellent results, the rather disappointing improvement on the 1919 plots is probably due to difficulties in heavily grazing a high exposed hill; nettles and thistles are increasing here on the top-dressed plots. At Halltree and Cliftoncote there was little increase of clover, though the botanical analysis showed evidence of considerable grazing and the turf was fairly well consolidated. It is significant that at both these centres the experimental plots were laid out on land heavily grazed at lambing time, but inspection and analysis of turfs showed that in autumn the clover was smothered in grass. This grass was heavily grazed in early summer, the land supplied with abundant droppings, then the herbage is "hained," hence the strong growth of grasses. In this special case of lambing pastures, it would seem that slag and mineral phosphates as top dressings do not seem to last long. It is noteworthy, however, that both places suffer severely in a dry season, which is adverse to white clover.

C. Untreated herbage grazed down in parts, but rough in patches—five centres—Broombaulks, Letham, Foulshiels, marked improvement and increase of clover with slag, less grazed down with mineral phosphates; Davington, marked improvement with both slag and phosphates, but not much increase of clover; Saughtree, moderate improvement and increase of clover with both. In this group the top-dressings have had a marked effect in increasing grazing, and it is significant that the first four (*i.e.*, the better results) graze cattle in summer as well as sheep. Saughtree, is heavily stocked with sheep early in summer. Foulshiels reacted

quickly to slag, and was distinctly improved in September 1919; by 1922 the phosphates plot was almost as closely grazed down as the slag, and both carried abundant clover. Broombaulks and Letham, both high lying, came slower but the turfs examined in 1922 showed excellent results, thus agreeing with shepherd's reports. The lack of clover at Davington has already been noticed. At Saughtree the untreated herbage was distinctly one of the better types of natural herbage and had a considerable amount of clover; the reaction to top-dressings was soon evident, and in 1920 the shepherd reported that the stock had soon discovered the slag and phosphates plots. In 1922 (October) the rougher herbage was smothering the clover which was much better where there was more grazing.

D. Untreated plots fairly well grazed down all over, few flowering shoots—two centres—West Loch and Scabcleuch. At West Loch on an extensive open hill pasture the improvement in clover and grazing was very marked, both plots closely covered with white clover, but the mineral phosphates one is rougher. At Scabcleuch the response of clover was disappointing, but the reports agree as to increased grazing of the plots.

Duration of Phosphatic Top-Dressings.—In this series of experiments, 1919 to 1922, there is evidence that while most of the centres are still improving, others are going back. At Whitfield and Shaws the cause is evidently the undergrazed herbage with a thick surface mat. As pointed out above these are entirely adverse to growth of clover and to production of close-tufted short grass. The soils under rank grass and thick sod are acid, so that any effect of lime present in the dressings is soon lost, and it seems as if the phosphates were not available for plant growth. Under these conditions, dressings of slag or mineral phosphates may have some effect, but it will not last unless the herbage can be reduced by stocking. At Drochil where a marked improvement and increase of clover were observed up to 1921, and at Scabcleuch, the application of manures seems now to have lost its effect. In both cases the lie of the land made the plots liable to drought, and this combined with washing of phosphates out of the soil has affected adversely the growth of clover and thus reduced the grazing. These results indicate that on shallow or porous soils liable to drought, phosphatic top-dressings need frequent renewal. At Saughtree and Halltree, on fairly good soils, it may be that it is not phosphates that the soil requires. It has been noted in other experiments that unless a soil is deficient in phosphates, marked results cannot be expected.

An experiment bearing on the permanency of phosphates has come under our notice, one laid down for the College by Mr Allan Carruth, in March 1915, at Brotherstone (St Boswells) on a black soil, part of a natural fen-bog. Three plots were laid down:—(*a*) Slag, 8 cwt.; (*b*) Algerian phosphates, 4 cwt. (about equivalent in phosphates to slag); (*c*) Algerian phosphates, 8 cwt. The plots include a closer, smoother herbage towards a fence (Sheep's Fescue,

Fluff Grass, Crested Dogstail and some Meadow Fescue) and a rougher tufted herbage of Tussock Grass (*Aira caespitosa*), Wavy Hair Grass (*Aira flexuosa*), Bent, Mat Grass (*Nardus*) Sedges and Tormentil. The top-dressings have produced a close-grazed pasture especially on the better part, and all the plots are clearly marked off from a strip of untreated herbage that runs through them. White clover is not abundant either on the slag or the single phosphates (4 cwt.) plot, but is distinctly more abundant, though not in close mats, on the double phosphates (8 cwt.) plot. The double phosphates plot (September 1922) had a fresher green than the other plots, and there was evidence on both the slag and single phosphates plots that the rougher tufts were beginning to enlarge again and to encroach on to the previously closely grazed herbage. This is taken as an indication that the smaller amount of phosphates is becoming exhausted while the larger amount is still effective. A renewal experiment has recently been begun. It may be noted here that the increased grazing begun on the plots themselves has now extended away from them into the originally untreated herbage so that round the plots there has been a considerable amount of grazing.

These experiments, on the whole, prove that mineral or rock phosphates are a valuable top-dressing for grassland, comparable in results to that obtained by basic slag. It should be borne in mind that the basic slag now on the market, produced by the "open hearth" process of steel manufacture is not only less rich in phosphates, but considerably less soluble (*see* this *Journal*, July 1921 and October 1922). Mineral or rock phosphates have been observed to give better results where the rainfall is fairly heavy, as is the case in most hill districts. These phosphates thus seem to be suitable for top-dressing hill pastures provided that they contain a high total phosphate (60 to 80 per cent.), are very finely ground, and are applied at the rate of about 12 cwt. per acre.

AGRICULTURAL EDUCATION AND RESEARCH IN SCOTLAND.

ALEX. M'CALLUM, M.A., LL.B.

PART III.

The Edinburgh and East of Scotland College of Agriculture.

WHEN the second Board of Agriculture was set up in 1889, agricultural teaching at Edinburgh was being given in connection with the University Chair to regular students, and also in vacation courses to rural schoolmasters, and at the Heriot-Watt College to evening-class students. Certain extra-mural lecturers also offered courses in agricultural chemistry, botany and veterinary hygiene. The Board's policy, as we have already noted, was directed to establishing teaching centres responsible for all the grades and branches of agricultural instruction in the surrounding districts, and so avoiding haphazard allocation of public money

to unrelated teaching agencies. The first attempt at co-ordination in Edinburgh was the institution in 1892 of the Incorporated School of Agriculture, already noticed. While fulfilling quite a useful temporary function, the school did not quite meet the requirements of the Board's scheme, which was intended to correlate all the instruction from the University grade to that of the extension lecture course, and to secure the co-operation of county authorities who now, since the passing of the Local Taxation (Customs and Excise) Act of 1890, had funds at their disposal to promote technical education. Accordingly, while for several years the Board continued to pay their grants to the University, they suggested that the University Court should consult with the Highland and Agricultural Society regarding the consolidation of the scattered teaching agencies in Edinburgh in order that if the scheme were effectively seconded by the Technical Education Committees of the neighbouring County Councils it might result in the establishment of an important combined centre of instruction of various grades, alike for direct and systematic agricultural study, for the training of agricultural teachers, and for the organisation of extension work. In the event, the task of co-ordinating the agencies was entrusted to an influential joint administrative board consisting of representatives of the University Court and of the Highland and Agricultural Society with powers to add to their numbers representatives of County Councils or other bodies contributing to the expense of the consolidated scheme. The members of this Joint Board included the Lord Justice General, the Principal of the University, the Lord Provost of the City, Lord Stormonth Darling, Sir William Turner, Sir James Gibson Craig, the Master of Polwarth, Major Wardlaw Ramsay, the Rev. John Gillespie, and the secretary of the Highland and Agricultural Society. This Joint Administrative Board, created under resolution of the University Court of date 18th December 1893, met for the first time on 17th January 1894, under the chairmanship of Lord Justice General Robertson, who at that time held the office of Lord Rector of the University. The first duty of the Board was declared to be that it should decide all questions as to the mode in which the Board of Agriculture grant was to be administered, and to report to the University Court. It was further resolved that the following were subjects, the teaching of which might be subsidised from the grant, and that instruction in these subjects ought, if practicable, to be arranged for, viz.:—

1. Agriculture.
2. Chemistry as applied to Agriculture.
3. Botany " "
4. Geology " "
5. Natural History " "
6. Land Science.
7. Mensuration, Book-Keeping, Land Surveying.
8. Veterinary Surgery, including Farriery.

The teaching of forestry was also to be subsidised by the Joint Board, but as this was the subject of a separate grant and as the arrangements for its provision were of a special character, it continued to be dealt with on a different footing from the agricultural subjects.

Of these subjects as named in the above list, it was found on inquiry that classes were available in agriculture, agricultural entomology, and economics at the University; in agricultural chemistry and agricultural botany in extra-mural classes at Minto House; in agricultural zoology and veterinary hygiene at the New Veterinary College; and in agricultural book-keeping and surveying in classes arranged by the Incorporated School under whose auspices the classes in Minto House and the New Veterinary College were also conducted. In addition, evening classes in agriculture—elementary and advanced—were held in the Heriot-Watt College.

Eventually a two years' curriculum was drawn up for day class students. Evening classes were arranged to be held in Edinburgh, and a tentative beginning was made with extension lectures in the Lothians.

In the first session of the two years' curriculum the subjects taken were mensuration, mechanics, elementary physics and chemistry, botany, drawing and handicraft; in the second session, agriculture, agricultural chemistry, botany, zoology and entomology, veterinary science and forestry.

From the multiplicity of the subjects offered one is inclined to suspect that this curriculum must have been determined upon rather from the point of view of the institutions involved than from that of the student, as it hardly appears reasonable to expect from the unfortunate victim of such a course more than the merest smattering of knowledge of so many subjects studied in two sessions of less than six months each.

With the exception of botany which was taken at the Royal Botanic Garden, all the first year subjects were taught in the Heriot-Watt College. The second year subjects were given at the University, the Royal Botanic Garden and the Royal Dick Veterinary College.

The evening classes, held in the Heriot-Watt College, provided instruction in agriculture and allied sciences, horticulture and forestry. A number of the general classes of the College were also available to agricultural students.

The annual vacation courses for schoolmasters continued to be held at the University and the Royal Botanic Garden.

This full scheme did not come into operation until the beginning of the winter session 1895–96, but certain preliminary ventures were conducted during the winter of 1894–95, including a course of technical instruction in horticulture conducted in the evening at the Royal Botanic Garden, in conjunction with the Scottish Horticultural Association; a course of mensuration and field geometry, suitable for farmers, gardeners and others; a series

of lectures on poultry-keeping; and lectures on agricultural subjects at six centres in the rural districts of Midlothian. In 1898 an addition was made to the courses available by the institution of a month's course for farmers' sons.

The Board of Agriculture made it clear that they would expect to find evidence of local interest in the Edinburgh teaching centre shown by financial support being forthcoming, and accordingly the Joint Administrative Board, in the first instance, made appeals to the Town Council of Edinburgh and to the County Council of Midlothian for contributions to their funds. The Town Council agreed to subscribe £600 for the first year, on condition that they received representation on the Joint Board, and provided also that evening classes suitable to the needs of citizens would be made available; while the Midlothian County Council subscribed £120.

These contributions led to the reconstruction of the Joint Board on agreement come to by the Board, the University Court, the Highland and Agricultural Society, and the Town Council, to the effect that so long as the Town Council should continue to contribute £600 annually to the funds, the Board should consist of not more than four members appointed by the University Court, four members appointed by the Highland and Agricultural Society, four members appointed by the Town Council of Edinburgh, and three members appointed by contributing County Councils as should from time to time be arranged.

With this new constitution and with the provision of classes as described, the venture came to be designated the "Edinburgh School of Rural Economy," and was so known until it was merged in its successor the College of Agriculture.

The provision made for representation of contributing counties led to Fife County Council subscribing £20 in 1898, and being given one representative. West Lothian, East Lothian, and Perth followed suit in 1900 with £100, £50, and £25 respectively, and were each allowed representation. Two co-opted members were added in 1901—Mr F. Grant Ogilvie, Director of the Royal Scottish Museum, and Professor Robert Wallace of the University Chair of Agriculture.

The income of the School of Rural Economy, derived as we have noted from contributions by the Edinburgh Town Council and by certain County Councils and from Government grants, was expended by the School in allowances made to the University, the Royal Botanic Garden, the Heriot-Watt College, and the Royal Dick Veterinary College in proportion to the amount of specially arranged teaching provided by each of these institutions. In addition, each institution retained the students' fees paid for the classes provided by it.

In 1897 the administration of the Government grant in aid of agricultural education and research in Scotland was transferred from the Board of Agriculture to the Scottish Education Department.

This arrangement of agricultural instruction at the Edinburgh centre—the two years' course for day students, the month's course for farmers' sons, evening classes, vacation courses for schoolmasters, and a few extension lectures—was continued under the administration of the Joint Board of the School of Rural Economy until 1901, but it obviously fell short of the full development intended in the original scheme of the Board of Agriculture and adopted by the Education Department, inasmuch as the course of instruction given at the centre could not be regarded as altogether satisfactory, and also as the extension work in the counties was much too limited, both in amount and in respect of the area covered. We have seen that the only counties that so far had come into line in support of the School were Midlothian, Fife, West Lothian, East Lothian, and Perth, and the actual instruction or other work in these counties was insignificant. The importance of more being done in this line was emphasised on several occasions by the Education Department, who pointed out that the taking of instruction to those actually engaged in farm work was a necessary part of a properly organised system of agricultural education, and, moreover, that the county authorities were not likely to be greatly interested in the activities of a central school in Edinburgh unless these were so extended as to operate widely throughout the county districts of the province.

The difficulty was to get a starting point. The School could not well extend its operations without being provided with additional funds to maintain an extension staff; and, on the other hand, the counties were reluctant to contribute money until they had had demonstrated to them the usefulness of the School in providing educational facilities in their own districts.

The Education Department took the view that local contributions were important in the first place as likely to result in giving a proper direction to the work of the Central School, and in the second place as the only sure means of obtaining an adequate guarantee for economy of administration, inasmuch as representatives of contributing counties would regard increase of expenditure as implying increase of their local contribution. In 1899 Parliament voted an additional £2000 for agricultural education in Scotland and the Department took the opportunity to point out to the County Councils and to the Joint Board that the distribution of this extra grant might be conditioned by the amount of local support given by Councils from their local taxation funds.

In order to press the matter home a Conference of the authorities interested was called at the instance of the Joint Administrative Board for the purpose of considering what steps should be taken to secure better provision for agricultural education and research in the central and south-eastern counties of Scotland. The Conference was held on 2nd March 1901, and was attended by representatives of the University, the Town Council of Edinburgh, the Highland and Agricultural Society, the Edinburgh School of Rural Economy, and the County Councils of

Berwick, Edinburgh, Fife, Haddington, Kinross, Linlithgow, Peebles, Perth, Roxburgh, and Selkirk.

The Conference agreed that the scheme for agricultural education and research should be twofold, embracing (1) a Central College in Edinburgh and (2) extension teaching in the Associated Counties; and that a Board of Management should be constituted by giving representation to Town and County Councils according to the amount of their contributions to the funds, and also to the University, the Highland and Agricultural Society, and the Heriot Trust, and temporary representation to the Joint Board of Management of the School of Rural Economy. These elected representatives were given powers to co-opt four other members.

Most of the counties named intimated contributions and the above proposals were thereupon carried into effect. The Board of Governors of the Edinburgh and East of Scotland College of Agriculture was constituted on 3rd July 1901, and immediately took over the work of the School of Rural Economy, which body transferred to the College a sum of £689, being the balance of their funds. The College was registered under the Companies Acts, the Certificate of Incorporation being dated 28th July 1902. Of the College as thus incorporated Colonel R. G. Wardlaw Ramsay of Whitehill was appointed president. He had been a member of the Joint Board of Management of the School of Rural Economy from the first and he had acted as chairman of the Board of Governors of the unincorporated College. He was retained in the office of President until his death in 1921. Throughout his long connection with the work of the Edinburgh institution he maintained the keenest interest in agricultural education in general and in the affairs of the College in particular, and he conducted the business of the Board of Governors with the utmost efficiency, tact and dignity. The College and indeed the country owes to him a debt of gratitude which it is a pleasure to acknowledge. He was succeeded in the president's chair by Viscount Novar, who demitted office in 1922 on being appointed Secretary for Scotland.

Another personality closely identified with the early years of the College and with its predecessor the School of Rural Economy was Mr James Macdonald, secretary of the Highland and Agricultural Society, who acted as honorary secretary first to the School and later to the College pending the appointment of a full time official. His services to the cause of agricultural education in Scotland ought not to pass unrecorded. The first permanent secretary, the late Mr W. Scott Stevenson, took office in January 1901.

One of the first cares of the new Board of Governors was to make provision for the taking of instruction out into the county districts and to that end they appointed in November 1901, Mr William Bruce, B.Sc., as senior lecturer for county work and retained other lecturers on temporary appointments to give courses at selected centres in the associated counties, and to arrange also

for experimental and demonstration work to be undertaken in the counties. At a later date a permanent staff of county lecturers was constituted.

The central class teaching continued for some time to be given in the different institutions as under the School of Rural Economy, and Professor Wallace was made honorary director of studies.

In May 1903 the Education Department intimated that the College would be recognised as a Central Institution and that future grants would be made under Article 87 of the Continuation Class Code and would vary with the approved expenditure, estimates of income and expenditure to be submitted to the Department early in the financial year. The special minute of the Department referring to this recognition imposed certain conditions which virtually brought all the College activities within the purview of the Department—the whole scheme of work both at the centre and in the counties, the qualifications of all lecturers and teachers, all diplomas or certificates issued by the College, the entrance qualifications of students and all financial affairs.

So far the College had not had any visible corpus in the shape of buildings beyond rooms hired in India Buildings for offices, but it was felt from the first that some concentration of the central class teaching was urgent and this could be obtained only by the provision of accommodation specially adapted and equipped. Accordingly in January 1904 the governors resolved to acquire the premises No. 13 George Square, and the property was taken over at 15th May of that year. The house was altered, added to, and equipped at a total expenditure of close upon £10,000, the money being provided by public subscription, by contributions from Town and County Councils and from the Highland and Agricultural Society, and by grants from the Education Department.

The acquisition of the building and its adaptation permitted arrangements to be made for centralising the teaching of the central classes. The appointments of a chemistry and a botany lecturer were made and the classes formerly held in these subjects in the University and at the Royal Botanic Garden were transferred to the College, as were also the classes in book-keeping, land surveying and mensuration, and all the evening classes; agricultural engineering continued to be taught in the Heriot-Watt College and veterinary hygiene in the Veterinary College.

After conference with the Glasgow and Aberdeen colleges the governors in February 1905, adopted regulations for the award of a College Diploma in agriculture and a three years' course of study leading up to the Diploma was thereafter arranged. At the same time a two years' certificate course was also instituted.

Consequent upon a conference held on 17th November 1907, between the secretary of the Education Department and a deputation of the governors, a scheme of extension was drawn up by the governors and approved by the Department, with the special object of bringing the College into closer relation with the farming community and making available to agriculturists, as far

as practicable, the results of scientific research. The college province was divided into nine districts to each of which a resident lecturer and organiser was to be posted, his duties to include the organising of agricultural teaching in his district, the conducting of experimental work, and the giving of advice and assistance as occasion should arise. To help him in carrying out his duties a system of Local Advisory Committees was instituted.

By the passing of the Education (Scotland) Act 1908, the Residue Grant—the source from which local authorities had drawn the contributions made by them to the funds of the College—was merged in the Education (Scotland) Fund, and the local contributions came thus to be paid direct from the Government source to the College as a Central Institution named in the schedule to the Act, instead of being first transmitted to the county authorities and then being by them voted to the College, a specific annual sum being earmarked as "local" money even after it came to be paid direct from Government.

So far as organisation is concerned, the College had now reached the stage when it might be regarded in its final form; further developments would be merely additions and modifications. The two main divisions of the College work were more or less satisfactorily provided for. The day classes in conjunction with certain classes in the science faculty of the University provided a full course of instruction in agriculture and the allied sciences. Agriculture, entomology, geology, forestry, economics and agricultural law were provided only in the University. Agricultural chemistry, agricultural botany, veterinary science, bacteriology, book-keeping and agricultural engineering only by the College; while classes in general chemistry, general botany, zoology, and field engineering or land surveying might be taken in either University or College.

Evening classes where the instruction was of a more elementary character were held in the College in agriculture, agricultural chemistry, veterinary science, forestry, horticulture, botany and zoology.

A short course of five weeks' duration was given annually in January and February for those engaged in farm work, the syllabus covering two sessions' attendance. Courses of instruction for teachers of rural schools were also provided, one course for students in training and another for acting teachers.

The extension work was also well organised, fifteen lecturers and instructors being regularly on duty and other special lecturers being engaged as the need arose. A feature was made of carrying on at as many rural centres as possible, systematic classes where the instruction covered from twelve to twenty class meetings and might be continued into a second session. Shorter courses, special lectures, travelling dairy schools, field experiments and demonstrations, fruit plots, and bee-keeping instruction were also undertaken and advisory work of all sorts was attended to both by the county and the central staffs.

From the time of the establishment of the College in the George Square premises, the number of students in attendance advanced steadily, and in October 1909 a marked increase to close on 100 regular day students emphasised the need for the provision of further accommodation. The Governors then gave consideration to three suggestions—the removal of the College to the country, the acquisition of another and larger site in Edinburgh, and the extension of the buildings in George Square. The difficulties involved in taking the College to the country—difficulties of residential accommodation, water, gas and electric supply, and communication, together with the apparent impossibility of maintaining at such a College the University connection, led the Governors to abandon that plan, and on a comparison of available sites in the city they decided that the balance of advantage lay with the George Square situation. This decision was communicated to the Education Department who asked Mr A. D. Hall to report to them on the whole question of the organisation, development and future policy of the College. His report confirmed the views of the Governors, as after discussing alternative proposals he recommended that "the best plan for the College would almost seem to be the enlargement of its present site and the provision of a small farm on the outskirts of Edinburgh sufficiently near to be reached by tram or frequent suburban train service."

The Governors thereupon submitted their proposals in detail to the Department and were assured that these would have the Department's support and financial assistance.

Meantime, the Development Commission had been set up under the Acts of 1909 and 1910, and on the suggestion of the Department, the Governors applied to the Commission for a grant in aid of the College extension scheme. This application, together with those of the Glasgow and Aberdeen Colleges, was supported by the Scottish Office, Lord Pentland, then Secretary for Scotland, lending cordial assistance; and in March 1911, information was received that the Commissioners were prepared to recommend the Treasury to advance from the Development Fund a sum not exceeding one-half of the cost ultimately approved for the desired provision of a farm and of college buildings, on condition that the balance of the expenditure required was met by local contribution and by a grant from the Education (Scotland) Fund—one quarter from each source—the amount available from the Development Fund not to exceed £60,000 for all the three colleges. An appeal was immediately made to the local authorities in the College area, and in response a sum of close upon £10,000 was promised. The Governors thereupon proceeded to negotiate for the purchase of two properties adjacent to the College building in George Square. On account of special and peculiar circumstances a Provisional Order had to be obtained for compulsory acquisition of one of these properties and negotiations were unduly prolonged; but eventually both properties were acquired for a total sum—exclusive

of legal expenses—of £8400. Plans were prepared for new buildings on the cleared site of the two houses, and these were approved by the Board of Agriculture for Scotland and passed by the Dean of Guild Court. [The administration of grants from public funds to the Agricultural Colleges had passed from the Education Department to the recently constituted Board of Agriculture for Scotland on 1st April 1912]. Meantime, the War Office had bought the estate of Dreghorn, about five miles from the city, and the suggestion was made that the College should take over the mansion house as a college building and the farm and policies, apart from the portion reserved by the War Office, for experimental, demonstration and teaching purposes. Thus the question again arose as to the location of the College, and the relative advantages and disadvantages of town site *versus* country site were keenly debated. The Governors did agree to lease the Dreghorn farm and actually occupied it for three and a half years; but after the war broke out the military authorities required more and more of the land for training soldiers and the Governors at length were obliged to terminate their occupation. The proposed transfer of the College was also departed from, and, in the event, the properties acquired in George Square had to be hastily adapted to provide accommodation for the great influx of students who flocked to the College after the declaration of peace.

This temporary adaptation of the George Square premises has added considerably to the laboratory and classroom accommodation, but it is of a makeshift character, and doubtless when a return to normal conditions makes reconstruction possible the problem of the college building will once more have to be considered.

After the occupation of Dreghorn Mains Farm was given up, the Governors were under the necessity of looking for a farm elsewhere, experience having convinced them that a College farm was an essential part of its teaching equipment. Several available properties were considered, and in the autumn of 1922 negotiations were completed for the purchase of the farm of Boghall on the eastern side of the Pentland Hills, about seven miles from Edinburgh. The farm extends to 580 acres, of which 233 are low ground, arable land of good quality and 345 acres are hill pasture. Occupation of the farm is to be taken by the College at Martinmas 1923.

Horticulture is of special importance in the east of Scotland, and accordingly instruction in that subject has from the first been included in the work of the College. Part of this instruction has been that of training rural teachers in school gardening and courses in this subject have been made available regularly at Edinburgh and occasionally at provincial centres, such as Perth and Cupar-Fife. At Edinburgh temporary accommodation having been found inconvenient it was necessary to provide permanent facilities for practical work, and in 1911 three acres of ground near Liberton were leased, laid out, and equipped with glass houses, lecture room, etc., mainly for this purpose. There also fruit plots have been

established and demonstration and experimental work carried on. At a later date additional ground was leased to make room for poultry runs and a bee-keeping establishment. In connection with horticulture a two years' day course leading up to a certificate was instituted in 1911–12, the curriculum being drawn up after consultation with the councils of the Royal Caledonian and the Scottish Horticultural Societies. A great deal of useful demonstration work has also been done on the fruit plots which have been established and carried on for a period of years in the counties of Forfar, Fife, Perth, East Lothian and Roxburgh; while the inspection and supervision of the numerous school gardens in the College area form no small part of the duties of the horticultural staff.

The Edinburgh centre may fairly claim also to have been the pioneer of the teaching in forestry in Scotland. Credit for this should be given to the Royal Scottish Arboricultural Society, who, in 1889, were instrumental in obtaining funds—including a grant of £100 from the Board of Agriculture—towards establishing a Lectureship in Forestry at Edinburgh University. The lectureship, first held by Dr Somerville, now of the Oxford Chair of Rural Economy, was to begin with of a temporary character, but later a permanent arrangement was made, and the Government grant was for a number of years paid to the University through the agency first of the School of Rural Economy and afterwards through the College of Agriculture. When, in 1919, grants from the Development Commission and money provided by the University authorities permitted the endowment of a Chair in Forestry, the payment from the College was discontinued. For some years the College Governors entertained the project of obtaining for teaching and demonstration purposes a forest garden in the neighbourhood of Edinburgh, and, indeed, in 1908 they selected an area at Penicuik which appeared suitable in every respect for the purposes they had in view. The Education Department were sympathetic towards the project, but insisted that they should be satisfied as to the usefulness of the garden to the students of the College: in other words, that such arrangements should be made as should give to the College an adequate share in the training of forestry students. Unfortunately, the University authorities at the time did not see their way to a compromise, and the Governors were obliged to depart from their purpose. Later, a nursery and some experimental plots were provided at Dreghorn for the University Forestry Department. For many years the College conducted special classes for practical foresters at local centres in the counties, and on several occasions also a month's course at Edinburgh; while an evening class in forestry was a regular and popular feature of the winter session until the present year, when the Forestry Commission, who are now responsible for education in forestry, through lack of funds, were obliged to ask the Governors to withdraw it.

The staff of the College has been considerably added to in

recent years. For the central teaching there are fourteen lecturers and assistants, besides the University professors and lecturers, whose classes are taken by the College students. A Lectureship in Agricultural Bacteriology was instituted in 1919, and one in Farm Accountancy in 1921. On the extension staff there are eight county lecturers and organisers, four horticultural lecturers, five instructresses in dairying and poultry-keeping and two lecturers in bee-keeping. There is also a small administrative staff, of which Mr Scott Stevenson was head until his lamented death in 1909, when he was succeeded as secretary by the present writer, who in the following year was made director. In October 1919, on the latter's transference to the service of the Board of Agriculture for Scotland, Dr Lauder became director of studies and Major T. Blackburn was appointed secretary, while in 1921 Mr W. Smith was made director of county work.

Besides the regular teaching, the staff carries out a large amount of advisory, experimental, demonstration and research work. The results of the experimental and research work are embodied in a series of reports issued from time to time. These deal with such matters as sheep and cattle feeding, variation in the composition of milk, composition of brewers' and distillers' grains, factors affecting the bacteriological content of milk, investigations into sheep diseases, potato culture, varieties of cereals and roots, improvement of old pasture, cultivation of vegetable crops, secretion of heather honey, etc., etc. Demonstration plots form a regular feature of work in the counties, and much useful information concerning suitability of new varieties of field crops to local conditions is in this way conveyed to the farming community. A useful form of demonstration has been that of the small-holding, the method being to select one holding of a group and arrange with the tenant to conduct his operations according to a plan laid down for him by the College representative, who supervises the work throughout. At convenient times the neighbouring holders meet at the demonstration holding and discuss with the College official points of interest connected with the management. Accurate accounts are kept of the finances, and reports on the holdings are submitted regularly to the Governors. These demonstrations have proved useful and helpful in the several districts in which they have been tried.

The advisory work of the staff is by no means the least important side of their activities, and this is recognised in the proposal which is now under consideration for the appointment of a small staff of permanent advisory officers, whose duty will be to conduct research into local problems, and advise farmers in respect of more abstruse scientific points which arise in the course of their practice. The Governors contemplate the appointment of specialists in agricultural botany and agricultural bacteriology.

Under the scheme of agricultural research drawn up by the Development Commission and the Board of Agriculture for

Scotland, the problems of animal breeding were allocated to Edinburgh, and a Joint Committee representative of the University and the College was nominated in 1913 to set up an organisation to carry out this work. It was not found possible to begin operations until after the war, but in 1920 a small staff was appointed, and accommodation was obtained in buildings belonging to the University in High School Yards. Since its inception the department has made considerable progress under the leadership of Dr F. A. E. Crew, and much interesting and useful work has already been accomplished.

FISH MEAL AND TAINTED BACON.

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AND

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In a previous article in this *Journal* (1) the writers gave an account of an investigation as to the food value of fish meal for farm animals. It was shown that this foodstuff is specially suitable to use as a supplement to starchy foods such as cereal grains, milling offal and potatoes, because it is rich in certain food constituents in which these are deficient, namely (*a*) mineral matter of the composition required for the formation of bone, and (*b*) protein, the flesh-forming material. On account of its richness in these constructive materials required for growth, it gives excellent results when fed, as part of the ration, to growing animals.

The extent to which the use of fish meal taints the animal product was also investigated. It was found that white fish meal, made solely from the heads, bones and adherent flesh of white fish, produces no taint in fresh pork, bacon, milk, eggs or chicken flesh. But a fishy taint was obtained in bacon from pigs fed on fish meal made from material which included herring residues. A similar result followed the feeding of fish meal which was purchased without any information as to the raw material from which it was made.

It is interesting to note that, although the feeding of fish meal made from material containing herring residues led to a distinct fishy taint in the bacon, no taint was observed when the flesh was used as fresh pork. Professor Haakon Isaachsen of the Norwegian College of Agriculture (*Norges Landbrukshøiskole*), who is at present engaged in an investigation on the utilisation of fish residues, has informed us that he has obtained a similar result with fresh pork. It is evidently the curing that brings out the

objectionable flavour when meal made from herring residues is used.

In these earlier experiments, the white fish meal that gave no taint had only 2·3 per cent. of oil, whereas the meal that gave the taint had 6·4 per cent., and since, on theoretical grounds, oil is the constituent that might be expected to give a taint, it was supposed that the taint arose from the oil. It is very desirable that definite information on this point should be available, because it has been suggested that fish oils, and especially cod-liver oil, should be added to the ration of pigs to ensure a sufficient supply of "Vitamin A," which has been claimed, without any very satisfactory evidence, to produce remarkable results when fed to pigs.

The experiments recorded below were therefore carried out to obtain an answer to the following questions:—

(1) Does the addition of cod-liver oil or herring oil to a ration fed to pigs result in a fishy taste in the bacon?

(2) To what extent does the addition of these oils result in improved health or rate of growth?

EXPERIMENT I.

The Influence of Fish Oils on Growth in Pigs and on Taint in Bacon.—Twelve young pigs from two litters were divided into four groups. Each group contained two pigs, 106 days old, from one litter, and one, 96 days old, from the other. The pigs were arranged so that the average weights of the four groups were almost equal.

All the groups were fed on the following ration, which contained fish meal of the same quality as that which had been used in the earlier experiments, and which was known not to produce a taint.

	Proportions.
Maize	10
Oats	1
Sharps	1
Fish Meal	2

The following oils were added to the food of three of the groups. To the fourth maize was added in sufficient amount to yield the same energy or starch value as the oils.

Group I.	Group II.	Group III.	Group IV.
Cod-liver Oil.	Herring Oil.	Olive Oil.	Maize.

The amount of oil added in each case was 60 c.c. for every 7 kilograms of the ration, *i.e.*, about 2 ozs. to 15 lbs. Cod-liver oil is the richest known source of "Vitamin A"; herring oil is also said to be rich in it; olive oil contains none. The amount of food given was regulated by appetite, the animals being fed as much as they could clean up.

RESULTS.

Gains in Weight.—The following table shows the rate of increase in weight in the different groups:—

	No. of Pig.	Weight in lbs.				Average gain per day.	Lbs. ration per lb. gain in weight.
		Aug. 21	Sept. 21	Oct. 21	Nov. 25		
GROUP I.							
Cod-liver oil .	257	56·3	98·1	145·0	209·7	...	...
	262	68·0	120·6	172·9	257·4	...	...
	328	39·8	72·2	112·4	161·9	...	...
Average .	...	54·7	97·0	143·4	209·7	1·6	3·7
GROUP II.							
Herring oil	258	51·3	93·9	149·6	228·4	...	...
	261	70·4	118·4	173·1	252·5	...	...
	327	40·5	69·3	108·9	156·8	...	...
Average .	...	54·1	93·9	143·9	212·6	1·63	3·47
GROUP III.							
Olive oil .	256	57·4	104·3	157·9	233·8	...	...
	263	71·5	115·9	176·0	250·8	...	...
	324	33·9	59·8	97·9	147·8	...	...
Average .	...	54·3	93·3	143·9	210·8	1·61	3·52
GROUP IV.							
Maize .	255	56·3	96·0	144·7	207·0	...	...
	260	68·9	122·1	183·9	260·2	...	...
	325	40·0	69·3	97·9	156·6	...	...
Average .	...	55·0	95·8	142·2	207·9	1·58	3·59

Note.—The figures in the last column showing "Lbs. ration per lb. gain in weight" do not include the oils or extra maize. They may be taken as equal in food value in all the groups.

The rates of gain in weight in the different groups are almost uniform. The animals getting the cod-liver oil, rich in the vitamin, did no better than those getting olive oil, which contains no vitamin, nor than those getting the maize. The amount of food eaten per pound of live-weight increase is rather greater in the cod-liver oil group than in the others. As far as rate of growth is concerned, therefore, the addition of vitamin-rich cod-liver oil, for the period of the feeding test, showed no beneficial result.

Taint.—One pig out of each group was continued until February 25th, and the amount of oil fed was increased from November 28th to 50 c.c. (about 1¾ ozs.) each per day, in order to intensify the effect of the oil in producing a taint. On February 25th the animals were killed and sent to be cured.

The bacon from all the pigs was too oily, as might have been

expected from the amount of oil fed. Even the animal fed with the extra maize was too fat to make good bacon.

With regard to taint, the result was decisive. The bacon from Group II. (herring oil) had such a marked offensive fishy taste that it was quite uneatable. The bacon from Group I. (cod-liver oil), though perhaps not quite as offensive as that from Group II., had also a distinct fishy taste.

In the experiments dealt with in the previous paper in this *Journal* the fishy taint was got with the fish meal containing 6·4 per cent. oil, but not with that containing 2·3 per cent. oil. These results, taken in conjunction with those now obtained, seem to indicate that, as had been supposed, it is the fish oil that causes the taint, and that the tendency of fish meal to cause a taint in the bacon is in proportion to the percentage of oil present.

EXPERIMENT II.

The Relative Value for Growth of Fish Meal Rich in Oil and Fish Meal Poor in Oil.—In this experiment the relative value for the growth of pigs of a fish meal naturally rich in oil was compared with that of a fish meal poor in oil.

Two groups of pigs were arranged as before, comparable as to litter and average weights. Each group was fed *ad lib.* on the same ration as that used in Experiment I., except that in Group I., fish meal with approximately 20 per cent. of oil was used, and in Group II., fish meal with 3 per cent. of oil.

The following table shows the rates of gain in weight:—

	No. of Pig.	Weight in lbs. Feb. 22	Mar. 24	Apr. 23	May 3	Average gain per day.	Lbs. food per lb. gain.
GROUP I.							
20 % Oil	518	73·9	107·6	152·0	158	...	...
	603	66·0	100·1	160·0	175	...	...
	571	59·4	95·7	141·0	148	...	...
	573	46·4	85·6	122·5	125	...	...
Average	...	61·4	97·3	143·9	151·5	1·27	3·46
GROUP II.							
3 % Oil	500	79·4	130·2	181·0	189	...	...
	601	67·5	100·1	144·5	153	...	...
	572	48·8	82·3	119·0	128·5	...	...
	574	52·1	83·4	127·0	136	...	...
Average	...	61·9	99·0	142·9	151·6	1·26	3·47

The result is in accordance with that of Experiment I. The animals receiving the oily fish meal made no better gains in weight than those receiving the meal with a low percentage of oil.

Discussion of Results.

Influence of Oil on Growth.—The value of the addition of fish meal to a ration of cereals fed to growing pigs is well recognised. The resulting increase in the rate of growth is so marked that practically all experimentors who have carried out feeding tests with this meal are in agreement on this point.

The remarkable results claimed to have been obtained in rats and guinea-pigs with "vitamins" have led, in some quarters, to the belief that the beneficial effects of fish meal must be due to the "fat-soluble vitamin" present. As a matter of fact, it is extremely unlikely that fish meal contains any appreciable amount of this vitamin. The process of manufacture is such that whatever may be present originally is likely to be completely destroyed. In any case, the results of the experiments recorded here show that the addition of vitamin-rich oil to a ration containing fish meal leads to no increase in the rate of growth.

In certain cases, however, where the ration is badly balanced, and especially in case of mineral deficiency, the addition of cod-liver oil, or certain other oils, leads to greater assimilation and retention of lime, and consequently to an increased rate of growth. It is doubtful, nevertheless, whether this is due to a vitamin. Work done here by Husband and others, which will be published shortly, shows that the same effect can be obtained from linseed oil, which contains very little vitamin, or olive oil, which, according to Report No. 38 of the Medical Research Council, contains none.

Recently Drummond, Zilva and Golding (2 and 3) who carried out some experiments with pigs in connection with an investigation on rickets, have recommended the use of cod-liver oil on the grounds that the fat-soluble vitamin it contains stimulates growth and improves the general condition. These writers fed two young sows on toppings (wheat middlings) and whey. After a time the animals stopped growing. The stoppage of growth was most probably due to lack of lime. Orr and Husband (4) have shown that a rapidly growing young pig needs nearly ½ oz. of lime per day, and the proportion of lime to phosphorus in the ration should be about equal. Kellner recommends that, in addition to the lime likely to be in the ration, the young pig should have 5 to 12 grams of chalk (carbonate of lime) added to its ration per day. It requires about 40 lbs. of middlings to yield ½ oz. of lime, and that amount of middlings yields ⅛ lb. of phosphorus. In whey the minerals are better balanced, but the percentage of lime is only a fourth of that in sow's milk. The experimental animals getting the middlings and whey must, therefore, have been suffering from a deficiency of lime, and a large excess of phosphorus.

When the animals stopped growing, cod-liver oil was added to the ration of one sow, and lucerne to the other, whereupon growth recommenced. The animals were then served and the original ration of middlings and whey resumed and continued until they

farrowed. The young from the sow that had received the cod-liver oil were born defective and all died. The young from the sow getting the lucerne were all normal and healthy.

The results of this experiment merely show that, on a mineral deficient diet, cod-liver oil is beneficial, but, in this case, it was evidently not as effective as lucerne, which is very rich in lime and iron, both of which are deficient in the toppings and whey ration.

These writers carried out a later experiment where the results were not so badly complicated by deficiency of minerals, as a salt mixture was added to the diet. They fed two young pigs from four days old on a diet resembling sow's milk in composition, but rigorously restricted in fat-soluble vitamin. The constituents of the diet were subjected to heating under pressure and extraction with alcohol or petroleum, to ensure that little or no vitamin should be left. Other two pigs from the same litter were fed on a diet of similar composition, except that it had an abundance of the fat-soluble vitamin. At the beginning of the experiment the two pigs on the vitamin-free diet, which had been treated as described, had little appetite for the stuff. They ate little and grew little, and one died. The remaining one had some cream added to the diet, whereupon it began to eat and grow. After thirteen days the cream was stopped, but the animal continued to eat and to grow, "even better than the animals in the control group," which were getting the fat-soluble vitamin. The experiment began on September 17th. On November 26th the weight of the pig on the diet "rigorously restricted in the fat-soluble vitamin" was 72 lbs.: the weights of those getting fat-soluble vitamin were 65¼ and 72¼ lbs. respectively. At the end of the experiment the pig on the diet that contained no vitamin appears to have been growing faster than the others, and was at least in no worse condition. Those getting the vitamin had "commenced showing weakness in their legs."

In a later paper these writers state that "a sow, even when fed on a diet deficient in the fat-soluble factor, and having undergone a previous deprivation in this factor, is capable of rearing her young satisfactorily." These carefully conducted experiments, the cost of which was defrayed by the Medical Research Council, are of great value to the practical pig feeder. They prove that the pig is not liable to suffer from deficiency of fat-soluble vitamin on any ration likely to be fed.

It is easy to agree with those writers in their view that the requirements of the pig for the fat-soluble vitamin are "not of a high order," but, in view of the results of these experiments, it is difficult to understand on what grounds they recommend the practical farmer to feed ¼ to ½ oz. of cod-liver oil to young pigs, and 1½ to 2 oz. to sows.

Crowther (5) has carried out some practical feeding experiments which are of interest in the present connection He was testing the value of certain feeding stuffs for pigs, and included fish meal and cod-liver oil in his tests.

A control group were fed with bran, sharps and barley meal, with no additions. A second group had cod-liver oil added to the extent of ½ oz. per pig per day. In a third group part of the barley meal was replaced by fish meal, to an extent which made the fish meal constitute 11¼ per cent. of the whole ration.

The following results are taken from a table given by Crowther:—

	Live weight increase in 68 days.	Weight of food consumed per lb. live-weight increase.
Cereal ration	61·0	4·58
Cereals cod-liver oil	64·9	4·54
Cereals fish meal	86·6	3·82

Cereal grains are deficient in mineral matter, and the addition of oil, as stated above, increases the assimilation and retention of minerals, and so improves the rate of growth; but the fish meal, which is rich in mineral matter, though containing little or no vitamin, shows a much better result with regard to rate of growth, and profitable gains in weight, than the vitamin-rich cod-liver oil.

Crowther concludes that the results "indicate no lack of 'fat-soluble vitamin' in the cereal meal ration, since any deficiency would have been remedied by the cod-liver oil, which would then have caused a marked improvement in the rate of growth, and a decided fall in the weight of food required to produce 1 lb. of live-weight increase;" and later: "the more effective utilisation of food obtained by the use of fish meal must therefore have been due to some factor other than vitamin-supply." This other factor, as the present writers have shown, is the rich mineral and protein content of the fish meal.

From the results of these and other experiments not referred to here, Crowther gives as his opinion that "it would seem very doubtful whether for a great part of our pig-feeding practice the 'vitamin' supply is of such practical importance as some popular expositors of this fashionable dogma would have us believe."

White and Roberts of the University College of North Wales have recently (6) published the results of practical feeding experiments which confirm Crowther's work. They fed pigs on thirds, decorticated earthnut cake and fish meal. One group was confined and another group was allowed to graze, to enable them to get green food, rich in fat-soluble factor.

The results were as follows:—

	Period in days.	Average daily increase per Pig.	Weight of meal to 1 lb. live-weight increase.
Indoor	112	1·37	3·26
Outdoor	112	1·35	3·29

The pigs getting the vitamin-poor ration made as good gains in weight, and were in as good general condition as those getting in addition the vitamin-rich green food. These workers hold that their results have demonstrated that an ordinary farm ration is sufficient to provide the "vitamins" required by young pigs.

The experiments recorded here, and those of the other writers referred to, have confirmed the results obtained in an earlier investigation by Captain Elliot and the writers (7). These showed that the growing pig is not likely to suffer from deficiency of fat-soluble vitamin on any otherwise properly balanced ration that would be fed in practice.

Influence of Oil in Producing a Taint.—The tainting of the bacon made from the pigs receiving the oil in Experiment I. leaves no doubt in our minds as to the influence of either herring oil or cod-liver oil in producing a taint. The amounts of oil used were large, and the taints were proportionally distinct. Since in the earlier tests, fish meal with 2·3 per cent. of oil was fed, to the extent of a sixth of the ration, without any taint being produced, there can be little doubt that the objectionable taste obtained in the bacon from these pigs was due to the oil.

Drummond and his co-workers had no evidence of flavour or taint in the flesh of pigs which had received cod-liver oil. They say: "We have not ourselves observed taint in pigs even when fed on a rather crude sample of oil." As has been shown above, a distinct taint may appear in cured bacon, though not detected in the fresh pork. It is not clear whether these workers themselves actually tasted the *bacon* made from the cod-liver oil fed pigs.

Crowther (5) found that no definite taint in bacon was obtained when fish meal was fed, nor when cod-liver oil was used to the extent of ½ oz. per day. The amount of oil fed by him was only about a third of that given by us in the later part of the experiment, and it was fed for a shorter time, 68 days compared with 187 days. It looks as if there was a limit up to which oil might be fed with safety. The limit probably depends on the nature of the oil, and probably also upon the method of curing.

It seems reasonable to assume, at least as a working hypothesis until further information is available, that the fishy taste sometimes got in bacon from pigs fed on fish meal is due to the oil present in the meal. As the safety limit is unknown, it is a dangerous practice in feeding bacon pigs to use oily fish meal, or to add oil to the ration.

Practical Conclusions.

It has been shown that cod-liver oil or other fish oil fed to pigs is liable to produce an objectionable taint in bacon. It has also been shown that the addition of these oils has no beneficial influence on rate of growth or health of the animals, provided the ration is well balanced with regard to the known necessary food constituents. There is, therefore, no advantage to be gained by adding fish oil to fish meal, or other food stuffs fed to pigs. In

the case of bacon pigs the practice is liable to render the bacon unsaleable.

Fish meal is such a valuable food for growing pigs that it would be a loss to the farming community if the use of it had to be stopped on account of the liability to spoil the bacon. It seems desirable that fish meal manufacturers should make certain that the fish meal sold to be fed to fattening pigs is made only from non-oily white-fish residues.

Oily fish meal need not be discarded as a food stuff. It can be used for boars, brood sows, and probably with perfect safety for growing cattle. But the manufacturer should place a distinctive mark on the bags to warn the users that the meal is liable to taint bacon. With white fish meal, with a low content of oil, there is no danger in using it, even to the day of slaughter. If, however, the feeder is in doubt as to the quality, he can avoid the possibility of injury to the bacon by cutting out the meal altogether for two or three weeks before slaughter. Indeed, this might be adopted as a routine procedure, because it is in the earlier stages of growth that fish meal has its special value. It is doubtful whether it is an economical feed during the last fortnight or three weeks of the fattening period.

Note.—The writers wish to acknowledge their indebtedness to Dr I. Leitch for arranging and verifying references, and otherwise assisting in preparing this paper for publication.

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FARM PROFITS AND FARM LOSSES.

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DURING the last eight or nine years a large amount of time and attention has been devoted in the Department of Agriculture of this University to the study of the economic possibilities of farming in Yorkshire under varying conditions and different methods of farming. Possibly in no county could so large a variety of different systems of farming be met with, and in the selection

of the farms which we have been studying, care has been taken to get as wide a range of types as possible. At the present time fifty-two such farms are under investigation. These farms include rearing, breeding and feeding farms; sheep farms; wold farms; warp farms; small-holdings; mixed farms for corn and stock; light arable farms specialising in rye, potatoes, carrots and peas; heavy arable farms specialising in beans, wheat and winter feeding of cattle; farms specialising in milk production; on mixed farms; on grass; on arable farms on the soiling system and on arable farms with the use of silos. *On the whole of these farms whose accounts for the past year have up to the present been completed there has been an average net loss of £2, 10s. 6d. per acre, a loss equivalent to 16 per cent. of the capital invested, or 1·82 times the rental.* Although there was an average loss of £2, 10s. 6d. per acre on the whole of these farms, very widely varying economic results were obtained from different individual farms. No less than 38 per cent. of these farms even last year were enabled to pay their way. That these results may be taken as typical of what has been happening in the farming industry last year is borne out by the fact that they agreed very closely with the results obtained on nineteen other Yorkshire farms whose accounts were last year kept by a well-known chartered accountant. On the whole of these sixty-two farms of 17,192 acres, whose accounts have at the time of writing been completed, there has been a net loss of £41,337, a loss of £2, 8s. 1d. per acre, or of 17·2 per cent. of the valuation.

YEAR 1921–1922.

Summary of Results on Sixty-two Yorkshire Farms.

Acres	17,192
Income	£256,920
Expenditure	248,742
Excess income over expenditure	£8,178
Income per acre	£14 18 10
Expenditure	14 9 4
Excess of income over expenditure per acre	£0 9 6
Initial valuation	£293,331
Final	243,816
Fall in valuation	£49,515
Initial valuation per acre	£17 1 3
Final " "	14 3 9
Fall in " "	£2 17 6

Gross loss - - - - - -	£48,935
Gross profit - - - - - -	7,598
Net loss - - - - - -	£41,337
Net loss per acre - - - - -	£2 8 1
Net loss in terms of valuation - - -	17·2 per cent.

It is, however, interesting to notice that on the whole of these farms the total gross income amounted to £256,920 and the total gross expenditure to £248,742, an excess of income over expenditure of £8178 or of 9s. 6d. per acre. This means that the total average net loss was due to the depreciation of the capital rather than to a loss on the trading account for the year. When it is remembered that the average capital invested on the farms under investigation in 1914 was little more than £10 per acre, and that with rising values that capital increased in 1920 to well over £20 per acre and has since fallen, until at the end of March 1921 it stood at £17, 1s. 3d. per acre, and at the end of March 1922 at £14, 3s. 9d. per acre, it will be seen that in the case of those farmers who have been farming since the outbreak of the war, their present farm valuation will still be standing at from 40 to 50 per cent. above the pre-war figure. In the case of those men who started farming in or after 1919, there is no doubt about the losses which the farm accounts show being actual losses, for these men entered the farms on a high valuation.

When we include the whole of the farms whose records are given, those whose accounts have been investigated through the University and by the chartered accountant already referred to, 29 per cent. of them still more than held their own.

1·6	per cent.	made profits of	more than £10		per acre.
3·2	„	„	from £4	to £6	„
6·4	„	„	„ £2	„ £4	„
17·8	„	„	„ £0	„ £2	„
19·4	„	made losses of	„ £0	„ £2	„
22·6	„	„	„ £2	„ £4	„
16·2	„	„	„ £4	„ £6	„
6·4	„	„	„ £6	„ £8	„
6·4	„	„	„ £8	„ £10	„

With such widely varying results it becomes, therefore, exceedingly interesting and instructive to examine the accounts more closely and see how far each individual farmer was more or less the creature of circumstances; how far his profits or losses were determined by the size of his holding, the type of farm, whether grass or arable, that he was farming, the variety of crop that he was growing or stock that he was keeping, the system of farming that he was adopting; and how far was the success or failure of

the holding determined by the individuality and personality of the holder. At the outset it may be stated without any hesitation that there is not a single farm that we have been on, without, when the accounts have been dissected and analysed, being able to lay our fingers on one or more points by the modification of which the losses of the farm could be decreased or the profits increased.

Size of the Farm.—As far as our results go, and it must be remembered that they are based on the records from sixty-two farms only, it would certainly appear as if the most productive type of farm and the one from which the best economic returns may be expected is one of approximately 150 acres. Of the four small-holdings under investigation, two held their own and there

VARIATIONS OF PROFIT AND LOSSES WITH SIZE OF FARM.

Size of Farm.	No. of Farms.	Acres.	Total. Profit.	Total. Loss.	Net per Acre. Profit.	Net per Acre. Loss.
Acres.			£	£	£ s. d.	£ s. d.
0 to 50 .	4	161	173	857	...	4 5 0
50 to 100 .	5	397	270	487	...	0 10 1
100 to 150 .	6	740	2,003	1,780	0 6 1	...
150 to 200 .	7	1,186	163	3,547	...	2 17 1
200 to 250 .	8	1,765	92	4,218	...	2 6 2
250 to 300 .	7	1,837	588	3,345	...	1 10 0
300 to 400 .	14	4,661	2,633	15,510	...	2 15 2
400 and over .	11	6,445	1,676	19,191	...	2 14 4
						Average.
Total . .	62	17,192	7,598	48,935	...	2 8 1

was an average net loss of £4, 5s. per acre. The small holder has undoubtedly been handicapped by heavy expenditure in rent, rates and labour, as the labour on these holdings cannot always be used to the best advantage. He has further been handicapped by the fact that the holdings are relatively highly capitalised and particularly by the fact that a very large proportion of that capital must be invested in implements and dead stock. Of the eleven farms whose acreage varied from 50 to 150, six were farmed at a profit.

Influence of the Proportion of Grass and Arable.—When the farms were classified according to the percentage of grass and arable land they contained, there was no doubt about the fact that it was the grass farms which last year held their own, and it is more than probable that when the results for the current year come to be analysed in detail, this fact will be brought out even still more strongly. On the purely arable farms with less than 20 per cent. grass, there was an average *loss* of £3, 4s. 3d. per acre; on the purely grass farms with more than 80 per cent. grass, there was an average *profit* of £3, 7s. 5d. per acre; on the mixed farms of from 21 to 40 per cent. grass in which case all the eggs there

were would not be put into one basket, there was an average *loss* of £2, 3s. 10d. per acre.

VARIATIONS OF PROFITS OR LOSSES WITH PERCENTAGE OF GRASS.

Percentage of Grass.	No. of Farms.	Acres.	Total. Profit.	Total. Loss.	Net per Acre. Profit.	Net per Acre. Loss.
			£	£	£ s. d.	£ s. d.
0 to 20 .	6	1,970	21	6,348	...	3 4 3
21 to 40 .	26	9,025	2,190	19,789	...	2 3 10
41 to 60 .	16	4,075	2,011	14,493	...	3 1 3
61 to 80 .	10	2,514	1,325	8,305	...	2 15 6
81 to 100 .	4	608	2,051	...	3 7 5	...
Total . .	62	17,192	7,598	48,935	...	Average. 2 8 1

PROFIT OR LOSS ON VARIOUS CROPS.

The economic returns obtained from the various 1921 crops will differ very considerably from those obtained from the 1922 crops, and from those which are likely to be obtained from similar crops in the future. On the farms under investigation of the 1921 crops—

Carrots left an average profit of .	£42 6 8	an acre.
Peas (picked green) left an average profit of	12 8 6	„
Peas (harvested) left an average profit of	7 7 11	„
Wheat (including subsidy of £3) left an average profit of . .	4 3 11	„
Oats (including subsidy of £4) left an average profit of . .	3 15 0	„
Barley, an average loss of . .	0 15 2	„
Potatoes, an average profit of .	3 7 1	„

Corn Crops.—The 1921 crop of wheat was grown at a cost of £12, 7s. 9d. per acre or £2, 6s. per quarter of grain. Apart from the subsidy of £3 per acre it would more than have held its own.

While the cost of production of the 1922 crop has not yet accurately been determined it is not likely to have fallen by more than 10 per cent. On the other hand comparing the selling price of wheat in February 1922 when it stood at 54s. a quarter, with that obtaining in February 1923 when it stood at 40s. 10d., it will be seen that during the last year there has been a fall in the selling price of more than 25 per cent. At the present time with the cost of production of wheat at least 80 per cent. and its selling price not more than 23 per cent. above the corresponding pre-war figures it will be evident that it will be almost impossible under such conditions to make the corn crops remunerative. If there is to be any hope of this it would appear that the cost of production must by some means or other be cut down to approximately £10

per acre and even then it would be necessary to grow at least 4½ quarters of wheat, 5 quarters of barley or 6 quarters of oats per acre.

TABLE V.

COST OF PRODUCTION OF CORN CROPS PER ACRE.
1921 CROP.

	Wheat.			Barley.			Oats.			Rye.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Rent	1	8	10	1	2	1	1	5	3	1	0	1
Rates	0	7	5	0	6	8	0	7	1	0	6	0
Seed	1	7	1	1	1	11	1	0	7	1	7	7
Manure	1	4	4	1	16	10	1	5	6	1	6	10
Share Cost of Cleaning	1	3	0	1	7	0	0	16	3	0	18	6
Incidentals	1	19	9	1	15	10	1	17	9	1	5	6
Labour (*a*) Man	2	18	9	2	13	3	2	12	9	1	15	5
„ (*b*) Horse	1	11	4	1	8	3	1	10	4	1	3	11
„ (*c*) Tractor	0	7	3	0	9	5	0	5	11	0	14	3
Total Cost	12	7	9	12	1	3	11	1	5	9	18	1
Yield per Acre—Grain	37 bush.			29¾ bush.			44½ bush.			26 bush.		
„ „ Straw	22 cwt.			14½ cwt.			18 cwt.			20 cwt.		
Cost per Qr. of Grain	£2	6	0	£2	15	9	£1	14	1	£2	15	1
Cost per Ton of Straw	£1	11	10	£2	7	8	£1	15	0	£1	8	0

Potatoes.—The 1920 potato crop was grown at an average cost of £24, 11s. 5d. per acre, or £4, 6s. per ton, and left an average profit of £3, 7s. 1d. per acre. Possibly no arable crop last year gave such widely varying financial results as did the potato crop. Prices held high right up to August 1922, but the economic returns from the potatoes on the different farms was determined possibly more by the freedom or otherwise from frost-damage early in November than by variations in yield. The 1922 potato crop must prove disastrous to practically every large potato grower. Owing to the fact that we had then under potatoes 560,000 acres as compared with 426,000 acres in pre-war days, the over-production of approximately half a million tons above our requirements would be bound to have its effect upon the price of the home-grown product. When, in addition to that, some 50,000 tons of Dutch potatoes were imported into England in July 1922, prices immediately fell to very little more than the corresponding 1914 figure. The following average prices of potatoes in the Leeds market during the year 1922 prove interesting reading:—

January	200/-	July	173/-
February	230/-	August	70/-
March	210/-	September	60/-
April	260/-	October	50/-
May	240/-	November	46/-
June	365/-	December	42/-

When, therefore, potatoes are costing approximately 90 per cent. above the pre-war costs and selling at the present time, if anything, below pre-war prices, there are bound to be heavy losses on the 1922 crop of potatoes.

Live Stock.

There can be little doubt that, during the next few years at anyrate, the mainstay of successful farming must lie in live stock.

Cattle.—On the whole of the farms "costed" through the University during the year 1921-22 there was an average net loss of £12 per head on the whole of the bullocks kept. This was due not to the fact that beef was selling at a remarkably low price, but to the phenomenally high price paid for the stores when bought in for feeding. In many cases bullocks bought in the spring of 1921 were sold at less than the price at which they were bought in, and on the average there was not a 10s. margin to cover the full cost of keep, in many cases for a full year. The following variations in the selling price per live-weight cwt. of fat stock during the financial year April 1921 to March 1922, will show the difficulties under which the feeder was labouring during that period.

Variation in Percentage Increase above pre-war level.

April 1921	168 per cent.	Oct. 1921	86 per cent.
May "	158 "	Nov. "	75 "
June "	120 "	Dec. "	65 "
July "	104 "	Jan. 1922	62 "
Aug. "	112 "	Feb. "	67 "
Sept. "	106 "	Mar. "	66 "

During the present financial year it looks as if bullock feeding should be quite a remunerative business, for the price of beef is being well maintained, and the buying in price of stores and young stock, though high, is still sufficiently low to leave quite a respectable margin. How far the market will be affected by the introduction of Canadian cattle yet remains to be seen. At any rate it is well to remember that during the coming Spring some 25,000 are likely to be shipped from Canada for this country, of which the greater number will be cattle, just under three years old, probably half fat and ready to be finished on the grass. As the market price of these across the water is approximately 24s. per live-weight cwt., their total cost landed in the United Kingdom should not exceed £2 per live-weight cwt.

Milk.—During the past year there has been an average profit of £4, 4s. 2d. per head on all the cows kept on the farms under investigation. The average cost of keeping a cow during the period 1921-22 amounted to £56, 11s. 9d., the average milk-yield to 590 gallons per cow, the average cost of milk production to 1s. 11d. per gallon, and the average price realised for all the milk sold off the farms—some wholesale and some retail—2s. 0¾d. There was, therefore, a margin of profit of approximately 1¾d. per gallon, a profit not large but very welcome in a year like the past.

In consequence of this a large number of farms are either increasing the number of cows in the herds or taking up milk production for the first time. Whether the effect of this will be to bring about over-production of milk (as has been the case with potatoes during the current year) remains to be seen. Two things, however, need to be remembered; the one, that the new milk trade is at present the one branch of farming industry in which the home producer has the monopoly; and the other, that the consumption of milk in England is approximately a quarter pint per head per day, less than one-third of the average consumption in America. If the consumption of milk could be increased—as it should be—in proportion to the increased production, the keeping of cows should still remain a profitable business.

The number of cows and heifers in England and Wales has steadily increased from 2,353,000 in 1920 to 2,501,000 in 1921 and to 2,522,000 in 1922, and the number according to the last returns is nearly 38,000 in excess of the corresponding number in 1914, an increase of nearly 15 per cent.

Sheep.—On the whole of the sheep kept on the farms there was last year a total loss of £1, 3s. 8d. per head. The results on the different farms varied very considerably, but when examined arranged themselves naturally under three heads. On practically all of the farms where permanent breeding flocks were kept, very substantial profits were made; the flying flocks just about managed to hold their own; while heavy losses, on the other hand, were made on nearly all those flocks where store sheep were bought in for feeding. Though the number of breeding ewes has been steadily increasing from 5,108,000 in 1920 to 5,428,000 in 1922, the total number of breeding ewes is still more than 20 per cent. lower than at the outbreak of the war, while the scarcity of store sheep is greater, the sheep—other than breeding ewes—in England and Wales in 1922 being little more than 8 millions, as compared with 10½ millions in 1914. As might be expected the price of mutton has been well maintained, and it has been the high prices at which the breeding ewes have been bought which has handicapped the flying flock, and the exceptionally high price of store sheep which has made the feeding of sheep unprofitable.

Pigs.—On the whole of the pigs on the farms "costed" last year there was an average loss of 17s. 1d., a loss accounted for almost entirely by outbreaks in the herds of swine fever, foot-and-mouth disease and swine erysipelas. Apart from this particular year, the keeping of pigs has for sometime past proved remarkably profitable, and at the present time the pig should be one of the most useful adjuncts to the farm. During the war the number of pigs on the farm—particularly of breeding sows—was considerably reduced, and although the number of pigs on the holding can be increased more quickly than any other kind of stock, the last recorded numbers showed a decrease of 8 per cent. on the pre-war numbers. The price of store and fat pigs has kept up probably better than that of any other live stock. In consequence we are

finding that more and more farmers are going in extensively for pigs, and practically all are increasing the number on the farms. At the present time well over 90 per cent. of the pigs, as far as our records are concerned, go for pork, and our ham and bacon market is almost entirely supplied from abroad. Approximately 25,000 tons of bacon each month or 300,000 tons per year are imported into England. There are at present fifty-six bacon factories in Denmark—in Yorkshire not one. If the increasing number of pigs be maintained in England to-day and all go for pork, the market for that commodity may soon be overstocked, though there is a market for bacon and ham which we are making little attempt to meet.

The average cost of keeping a pig worked out last year to approximately 3s. 1d. per week, and it would appear that the future success of the pig industry may be dependent upon two things—

(*a*) Cutting down the cost of keeping pigs (as it might be cut down) by the extension of the open-air system.

(*b*) Attempting to meet the demand not only for pork, but also for bacon and ham.

Poultry.[1]—Although a few of the poultry accounts have not yet been completely balanced, the results up to date show that there has been an average net profit of 11s. 5d. per bird, and only one farm has been met with on which poultry have not paid their way. The reason for these high profits are self-evident, namely, the facts that—

(*a*) The selling price of eggs and poultry during the past year has been maintained at well over 90 per cent. above the pre-war figures.

(*b*) Foodstuffs consumed by poultry are standing to-day at a figure not more than 40 per cent. above the pre-war prices.

As the food bill will form at least 80 and possibly 90 per cent. of the total cost of upkeep of fowls, it will follow that when the selling price of products from the poultry is 90 per cent., and the cost of upkeep of the poultry only 40 per cent. above the pre-war level, the industry should at the present time be in a very flourishing condition. The high prices which have been maintained have been due to the laws of supply and demand. According to the Ministry's Returns, there were in 1921 approximately 4 million less birds in the country than there were in 1913.

NUMBER OF POULTRY ON FARMS IN ENGLAND AND WALES.

	1908.	1913.	1921.
Fowls	28,249,000	29,026,000	24,816,000
Ducks	2,669,000	2,188,000	2,391,000
Geese	686,000	577,000	517,000
Turkeys	628,000	652,000	445,000

[1] *See* this *Journal*, April 1923, p. 166.

At the same time the imports of eggs from abroad, mainly due to Russia falling out of the market, have fallen from 2590 millions in 1913 to 1639 millions in 1922.

In the sphere of agriculture the poultry industry appears to be the one branch in which the demand is greater than the imported and home supply.

FARM PESTS.[1]

JAMES RITCHIE, M.A., D.SC., F.R.S.E.

Natural History Department, Royal Scottish Museum.

Mammal Pests—continued.

(4) DESTROYERS OF STORED GOODS AND PROPERTY.—Having completed our survey of the mammals which, directly or indirectly, do damage to the farmer's domestic stock, his crops or pasture, and his woods, we turn from the open field to enquire whether and to what extent his enemies pursue him when his grain is garnered and the crops he has raised and harvested with such laborious toil have been placed in a semblance of safety in structures of his own devising. Even here marauders press hard on his welfare; and although they be few in variety, their numbers and voracity more than compensate for this deficiency, so that the destroyers of stored goods form one of the most serious of all the mammal pests: it would almost seem that the last case of the farmer is worse than the first.

Rats.—Two species of rats live at the present time in Britain, the Black or Ship Rat (*Rattus rattus*), and the Common or Brown Rat (*Rattus norvegicus* or, as it was generally termed, *R. decumanus*). These two species differ in appearance and habits, as well as in numbers and economic importance in this country. Both are aliens in Britain, both are natives of the East, and we owe both to our shipping traffic with foreign lands—an early penalty of commerce and internationalism.

The Black Rat was the first to be deposited in Britain, but that was long ago, perhaps in the time of the Crusades, about the twelfth and early part of the thirteenth centuries. It soon made good its footing in this country, and was until the eighteenth century the predominant and indeed the only rat in Britain. It is to be distinguished from the Brown Rat in appearance, by its smaller size, more slender body, long head with pointed snout, and particularly by its large naked ears, so long that they easily reach the eyes when pressed forward, and by its long thin tail, as long as the length of head and body combined. Although its colour is, as a rule, black along the back and smoky grey on the belly, this is scarcely a safe guide, for one of its races, the Alexandrine Rat,

[1] Earlier articles of this series appeared in this *Journal* for July and October 1922, and January and April 1923.

of which I have examined specimens from colonies in Scotland, is brownish grey along the back and paler on the under parts.

But although the Black Rat was at one time predominant, and was a more persistent lodger in human habitations and out-buildings than its brown congener, it has long since been reduced to a few isolated and sparse colonies in Scotland, owing partly to the severity of the competition for food and breeding places, brought about by the establishment and increase of its larger cousin, and partly to the great improvement which has taken place in the conditions of dwelling- and out-houses. So that to-day the Black Rat cannot be reckoned a factor of any importance in the economics of British farming.

The Brown Rat.—Unfortunately such is very far from the truth as regards the Brown Rat, by which an almost incredible amount of damage is done yearly. From the Black Rat it may be recognised by its larger size, sturdier and heavier body, stouter head with blunt snout, and particularly by its short ears which do not reach the eyes when pressed forward, and are covered with a thick coat of fine hairs, and by its stout fleshy tail which is never so long as the combined length of head and body. The colour is, as a rule, the familiar greyish brown, but Mr Hinton states that a black race of this species is in process of evolution in Britain, and other colours, white, cream-coloured, and so on, sometimes appear as sports.

The Brown Rat is comparatively a newcomer to our shores. The date of its arrival in England is put at 1728 or 1729, and there is evidence that it appeared about the same time in Scotland. It made an astonishingly rapid conquest of the country, so that now it is established wherever man dwells, and has even invaded uninhabited islands, where it lives on shore refuse and, in their season, on the eggs and young of ground-nesting birds.

It is impossible here to discuss in detail the habits of the Brown Rat,[1] but the main facts, most of them well known, are as follows. It is pre-eminently a burrower; indeed it used to be known as *Mus fossor*, the digger. Its burrows are complicated underground tunnels, with many outlets and many branched passages, in the depth of which is placed a nest made of dry grass, ivy or other leaves, scraps of paper, or indeed any suitable material that may be available. In addition to the passage ways and the nest-cavity, excavations made at the Scottish Zoological Park show that the underground settlement may also contain a store chamber, in which are collected oddments of food, such as maize, pieces of turnip and the like, which may be available should access to outer food supplies be cut off. In the nest the female deposits a succession of litters throughout the year, and it is to her remarkable fertility that the rat plague is largely due. Commencing to breed even before she has reached full growth (she may have a

[1] I would refer the reader for an excellent account to M. A. C. Hinton's "Rats and Mice as Enemies of Mankind," No. 8 of the Economic Series published by the British Museum (Natural History).

litter when only eight weeks old) she produces some five or six litters a year, each containing on an average between six and eight young. It has been reckoned (by Zuschlaf) that a pair having six litters of eight a year, the young in which commenced to breed at 3½ months old, and allowing for equal sexes and no deaths, would produce by the end of the first year 880 individuals. There have been more staggering computations: Von Fischer estimated that the progeny of a single pair might in ten years amount to 48,319,698,843,030,344,720 rats. It is perhaps enough if we realise that the existence and survival of even a pair of rats contains a very serious potentiality of harm on account of the extraordinary fecundity of the species.

Rats are rodents, and originally may have confined themselves to a vegetarian diet, but as they have adapted themselves to almost all climates and conditions of livelihood, so they have become adapted to all kinds of food, and must be regarded as omnivorous. Grain, turnips, human food, birds and birds' eggs, young rabbits, the garbage of sewers, the refuse of city dumps; all is grist to the rat's mill.

Economic Significance.—The damage done by rats is only too well known; it depends upon their burrowing and gnawing habits, upon their feeding habits, and, in view of these, ultimately upon their powers of rapid multiplication and of adaptation to an infinite variety of circumstances. The monetary loss caused by their feeding habits alone runs to a very considerable bill. Suppose we apply to Scotland calculations which have been made for other countries. It has been reckoned that on an average the rat population of this country may be calculated at one rat per cultivated acre of land. This would give us in Scotland a rat population of approximately 5,000,000 individuals. Suppose we assume that each rat contents itself with food to the value of one farthing a day—a low estimate, for actual experiment, made in pre-war days, showed that the cost was actually more than one halfpenny, but some rats feed on garbage and refuse. On these assumptions the bill for feeding our Scottish rats would amount to £1,875,000 a year.

But in their feeding, rats do much damage not accounted for in so simple a calculation. It is not only that they devour grain, but they riddle the stacks in the farm-yard and eat into the sacks in the barn, causing much wastage. And what of their pillage in the poultry-yard, their theft of eggs and their slaughter of young and even old fowls, of their destruction of eggs and birds in the game covert, and of young rabbits in the rabbit warren? They seem almost to claim as a perquisite the right to feed on level terms with the pigs and the poultry, upon the food the farmer has provided for his own protégées.

There is another side to their harmful activities that cannot be ignored, the damage they cause to buildings and other property. Instances have been brought to our notice where boundary walls have had to be rebuilt, owing to their partial collapse because of

the burrowing of rats and the undermining of the foundations; and this in addition to their normal penetration of floors and wooden walls, and even of more substantial structures.

Apart from the direct and patent loss caused by the activities of rats, there is an aspect of their presence to which the farmer has, perhaps, given too little thought. Yet it is an aspect which, in the long run, may involve consequences more ruinous even than the evident damage; for it has now been proved up to the hilt that rats are active agents in the spread of disease.

To take first the case of domestic stock. Influenza in an acute form occurs amongst horses and ponies; without doubt such influenza may be and often is carried from one horse to another, and from one stable to another by rats. When a stable has to be closed because of an influenza epidemic, the disease appears in neighbouring stables, just because of the scattering of the infected rats which inhabited the first stable. The same agents even transport influenza from pit ponies in one mine to those in neighbouring mines.

Pigs are subject to a disease caused by the presence of a minute thread-worm, *Trichinella spiralis*, which occurs in the intestine or in the muscles. Fortunately, it is much less common than it used to be, and is rarer in Britain than in some parts of the Continent. But the Pork Thread-worm occurs also in rats, and the disease spreads amongst pigs through their devouring infected dead rats or food contaminated with the infected excreta of rats. Unfortunately, man also may suffer, and that fatally, from trichinosis (the disease caused by *Trichinella*), and although his infection is due to the eating of parasitised and improperly cooked pork, yet it is significant that an epidemic of human trichinosis occurs only where the common Brown Rat is plentiful. In Glasgow City Abattoir some years ago it was discovered that 3 per cent. of the rats were harbouring the Pork Thread-worm.

It has been stated, further, that foot-and-mouth disease is known to have been carried by rats.

In the second place, man himself does not escape from the evil influences of contact with these rodents. I have just mentioned the case of human trichinosis, the spread of which is largely due to the Brown Rat, and this species is also a carrier of dysentery. An even more serious charge lies on the head of the Black Rat, for it and its associated fleas are responsible for the spread of bubonic and, as a consequence, of pneumonic plague, which still claim their victims by thousands in the East, and occur in isolated cases almost annually in Britain.

The Prevention and Destruction of Rats.[1]—The destruction of rats is no longer an option left to be carried out or neglected according to the whim of the tenant of land. Parliament,

[1] *See* Leaflet No. 51 of the Board of Agriculture for Scotland, "Destruction of Rats,' and Miscellaneous Publication, No. 22, of the Ministry of Agriculture and Fisheries, "Rats: How to Exterminate Them, etc.," by R. Sharpe, 6d., post free.

recognising the seriousness of the rat problem, has definitely insisted that steps shall be taken to meet the necessities of the case. Under Section 1 of the "Rats and Mice (Destruction) Act" of 1919, it is laid down that "Any person who shall fail to take such steps as may from time to time be necessary and reasonably practicable for the destruction of rats and mice on or in any land of which he is the occupier, or for preventing such land from becoming infested with rats or mice, shall be liable on summary conviction to a fine not exceeding five pounds, or, where he has been served with a notice under this Act requiring him to take steps, not exceeding twenty pounds." The cost of the destruction of rats and mice is to be borne by the occupier of the "land" on which the operations are carried out.

It is impossible in the course of this summary to discuss in detail all the methods that have been used against rats. For these details I would refer those interested to the pamphlets already mentioned, and to Mr E. G. Boulenger's "Report on Methods of Rat Destruction," published by the Zoological Society of London (price 6d.). A few remarks may be offered, however, on the methods which have been found to be most practicable and most successful.

The question of the riddance of rats falls into two distinct categories. *Destruction of rats* is all very well, but it loses much of its charm if provision is left for the ingress of fresh hordes. It ought, therefore, to be preceded, or if that be impossible, supplemented by methods for the *prevention of rat infestation.* Food and stores should be kept in rat-proof receptacles; buildings where food or breeding places might be found should be made rat-proof by efficient protection of doors, windows and all possible points of ingress, as well as by the use of concrete in foundations and lower walls; drains should be sealed by rat-proof cages. Much may also be done to prevent infestation by the immediate destruction of rubbish, for rubbish dumps are notorious refuges and breeding places.

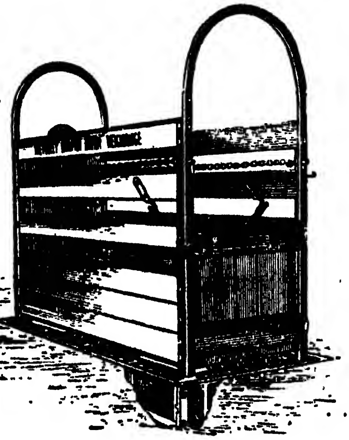
In response to a query as to the results of his practical experience of rat-prevention on Scottish farms, Mr T. Munro, Organising Officer under the Rats and Mice Destruction Act for the Board of Agriculture for Scotland, kindly sent the following observations :—

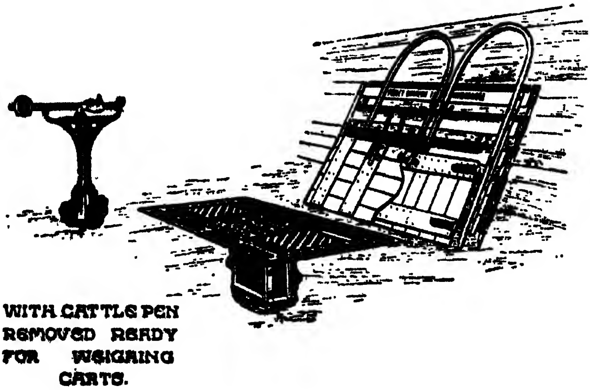
"Rat-proofing is the only way of permanently discouraging rats from invading or harbouring in buildings or enclosures, and rat-proofing must be kept in good repair. It is useless to put small mesh wire netting outside a granary window, and allow a hole to be made in the wire or the wire to rust away; or to concrete the floor of a stable, and let rat holes remain in the walls of the building. Where there is a water-wheel, whether used or not, there, as a rule, rats will be found. They find their way down the lade to the wheel, and from the wheel enter the millhouse through the shaft hole. Nothing is simpler than to fit a small mesh wire netting around this shaft so that rats cannot enter, yet in how few

POOLEY

CHAMPION FARMER WEIGHBRIDGE

No. 537.
ARRANGED READY FOR WEIGHING CATTLE.





WITH CATTLE PEN REMOVED READY FOR WEIGHING CARTS.

Full Particulars from:—
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farms are these wire screens fitted. In a well-kept farm inspected recently, in order to prevent rats coming down the lade and burrowing up from it into the stackyard, an intercepting tank of concrete had been constructed outside the stackyard. The rodents were unable to get any further along the lade than this tank, and a large pipe laid to the wheel made the water power installation rat-proof.

"Doors opening into a corn barn or granary often have holes at their base big enough to allow the largest rat to pass, or a large hole about 15 inches up for the use of cats, and incidentally of rats. Every door into any place where grain is stored should fit close to the flooring and have the lower portion of both the door and the jambs sheathed with metal. The hole for cats should be fitted with a round piece of wood large enough to cover it when fixed to the door just above the hole; the cover should swing freely, parallel and close to the opening. In a very short time cats learn to open this shutter, but it effectually keeps out rats.

"Many stacks are built with three poles in the centre for purposes of ventilation; rats climb by these interior poles into the upper part of the stack. Whins placed as a foundation will prevent rats gaining access to the foot of the poles. Around a newly erected stack there are usually placed a number of props to keep the stack in position until the straw settles down. These props should be removed as soon as can be done with safety. They offer an easy road for the rats to gain access to the stack. At the point where they touch the stack, the pressure of the overlying straw is relieved, enabling the vermin to obtain a footing well inside, from which they may burrow in any direction.

"Dry stone dykes around stackyards provide ample safe harbourage for rats; the dykes should be removed and replaced by wire fencing. Not only is harbourage done away with but a freer circulation of air round the stacks is obtained. At the farm previously mentioned this improvement was carried out with most beneficial results.

"A sufficient number of cats of the right breed about a farm will prevent it becoming infested with rats. As a rule a cat will not attack a large rat, but they keep down the supply of young ones. It is said a cat will die if its food consists mainly of rats and mice, and that a supply of milk at least twice a day is necessary to keep them in health on this flesh diet.

"Concrete and cement are the most useful agents for rendering buildings and steadings rat-proof. Those farmers who keep their steadings in repair, allow no rat holes to exist and reduce safe harbourage, invariably have few rats about their farms. A farm that was infested by rats was cleared by laying all the drains in concrete and then keeping a good stock of cats. The farm mentioned in the earlier portion of these notes was so badly infested when the farmer went into it, that with traps alone an average of about one hundred rats per week was killed for three months. The stables and steading were repaired, concrete and

cement were laid down, wallheads filled in and harbourage removed; with the result that now a rat is seldom seen about the place. The dwelling house on this farm was alive with rats. Their means of ingress could not be found. The farmer, who was also the owner, dug a trench around the house down to the foundations of the walls. The foundations were carefully pointed with cement, and a kerb of concrete was laid along the face of the wall up to ground level. This took place over ten years ago and not a rat has since been seen in that house

"Does it pay to rat-proof? This question is, perhaps, difficult to answer definitely from the farmer's point of view, but the following instances from urban areas, where actual figures are available, show that it does pay to keep rats out. It should be added that many similar instances could be cited.

"A large firm of wholesale grocers moved into premises which they found to be rat infested. They suffered heavy losses and great inconvenience owing to the destruction of their carton cases, bags and food. The building took eight months to rat-proof and the process cost nearly £300. The management state that within two years they will be saved more than this sum by having their premises rat-proof. In a branch shop of a well-known firm of grocers, the manager stated that he was invariably £20 to £30 short on taking stock every two months. On his representations the shop was rat-proofed at a cost of over £100. Since the alterations were carried out the credit balance of his stock over the old state of affairs averages £10 to £15."

In the consideration of these interesting examples from Mr Munro's own experience, it must be remembered that the cash saving actually set down is not the only gain from such rat-proofing. For premises infested as these were, harbour a large breeding colony, and the overflow from such a colony migrates to suitable areas in the neighbourhood; so that the benefits which follow the stamping out of a rat warren spread far beyond the rat-proof walls, falling alike on the heads of the just and the unjust.

The Destruction of Rats.—Freedom from rat infestation to be obtained by rat-proofing and such means as have been mentioned is an ideal state not easily attained and almost unattainable where old buildings and steadings are present. It must be supplemented by an active campaign directed against the rats in person, so that buildings freshly rat-proofed may start with a clean sheet, and so that the best may be made of a bad job, where complete rat-proofing is impossible.

The methods of destruction available are (1) encouragement or protection of the natural enemies of rats; (2) trapping; (3) poisoning with poisoned baits or virus; (4) fumigation with poison gases; and (5) hunting. Each of these methods may be looked upon as the best for certain definite circumstances and conditions.

(1) In the forefront of the methods of destruction available on farms I place the protection of the natural enemies of rats, first, because these enemies are permanent destroyers, ever-set traps at

work all the year round, requiring no special campaigning arrangements, no special preparation and no setting; second, because, apart from domestic cats, of the value of which as rat destroyers the farmer is well aware, they entail no cost in labour or upkeep;

THE SETTING OF A GIN TRAP IN RAT RUNS (*indicated by pencil lines*).
FIG. 1.—Correct method: Rat enters between jaws.
FIG. 2.—Wrong method: Rat thrown out by rising jaw or catch.

and third, because, given free play, they act like a self-regulating machine—the more rats the more enemies will appear on the scene to tackle them. Whatever other methods of destruction may be employed, they should always be supplemented by leaving the natural enemies to do their full and willing share. Amongst the most important of these destroyers—and it must be remembered that here we are discussing not game preservation but the

protection of the farmer's crops and stores—must be reckoned stoats and weasels; and amongst birds, the agricultural significance of which I hope to discuss in a future article, may be placed in order of merit, the barn owl, the brown owl and the kestrel.

(2) Trapping. This method of destruction will always hold an important place, because it is particularly suitable for employment where rats do not occur in very great numbers, and can be used with safety where poisoning or fumigation may endanger domestic stock or be otherwise impracticable.

There are many varieties of traps on the market, varying in their degree of efficiency less perhaps because of differences in mechanism than on account of the expertness with which they are used. The comparative catching power of various kinds of traps has been tested at the Zoological Gardens of London and is referred to in the pamphlet mentioned above; but it may well be that on a farm, trap-efficiency is determined by factors different from those in the highly unusual conditions of a zoological garden. The majority of traps fall into three groups: the steel gin trap; the break-back type; and the cage type. It is impossible to deal with all the multitudinous forms of these types, but I have selected standard traps to illustrate each group.

The steel gin is the familiar rabbit and vermin trap of the gamekeeper, but for rats a specially light pattern with 3 inch jaws is manufactured. Such a trap is set unbaited, and at an angle, in rat runs, secured by a chain and strong peg, and concealed by a thin coating of earth or chaff. Great stress is laid upon the necessity of laying a gin trap at an angle across the line of the run, as otherwise a rat may be thrown back from the jaws, either by the rising jaw or by the backward spring of the catch. The figures which illustrate Mr R. Sharpe's account of the process in the pamphlet issued by the Ministry of Agriculture and Fisheries are here reproduced through the courtesy of the Controller of the Stationery Office, to whom also we are indebted for the use of the block of Fig. 11, from the same pamphlet.

One of the latest examples of the gin type is the "Gilpa" rat trap, manufactured by Henry Lane, Ltd., and placed on the market by Messrs Gilbertson & Page (Fig. 3).

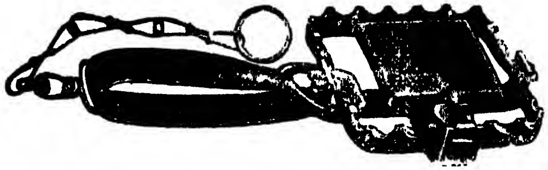

FIG. 3.—Steel Gin Trap. The "Gilpa," in set position.

The advantages claimed for this make are its cheapness, its lightness (weight 7 ozs.), its strength due to its being stamped from solid metal and thoroughly welded, the perfection of its spring, and the fact that it sets flat and can therefore be concealed with a

minimum of excavation. Similar traps in various degrees of quality and weight, at various prices, are also obtainable (Figs. 4 and 5).

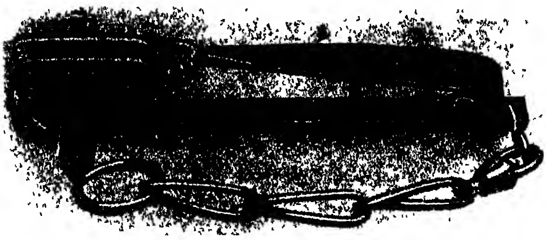

FIG. 4.—Ordinary Dorset Gin Trap (*Lane's Model*).

The break-back type is built on the plan of the familiar small wooden mouse traps, fitted with a movable platform which, when touched, brings a strong spring down upon the neck or back of the intruder. Rat traps of this type are of course larger, heavier

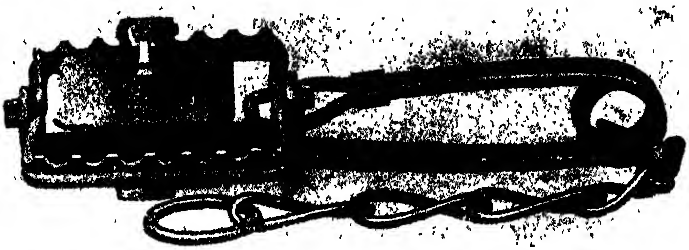

FIG. 5.—Wire Spring Gin Trap (*Lane's Patent*), combining lightness with great power.

and stronger than the similar mouse trap, but like it they are designed for the attachment of bait. There are several wooden models of break-back traps on the market, but a recently invented metal model, the "Ezi-set" patent trap, has several advantages (Fig. 6). Amongst these are to be reckoned its weather-proof quality, the simplicity of setting, all that is necessary after the bait has been attached, being that the spring should be raised sharply into set position, the possibility of adjusting the spring to increase or diminish the sensitiveness of the release, and the ease with which the trap can be taken to pieces and cleaned.

The experimenters at the London Zoological Gardens found that the efficiency of gin and break-back traps was increased if the traps were set in a wire tunnel, concealed under straw or hay. Such a model is illustrated in Fig. 7, where a trap is placed at each end of a through run formed by a wire tunnel. The type

illustrated is so arranged, owing to the simplicity of the "Ezi-set" mode of setting, that the traps may be set by a string attachment

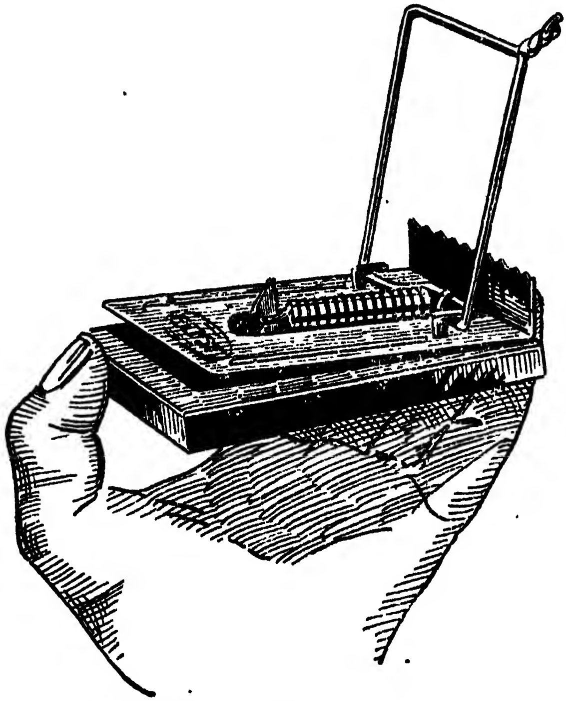

FIG. 6.—Break-back type. "Ezi-set" model. The illustration represents an "Ezi-set" Mouse Trap set. The Rat Trap is identical in pattern, but of larger size.

without any actual handling of the traps themselves, and may be easily set in awkward positions between sacks or bales, where ordinary models are difficult to manipulate.

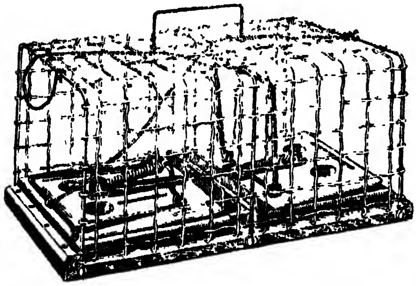

FIG. 7.—Tunnel Break-back Type, "Ezi-set" Model showing one trap (to right) set.

The cage type of trap depends for its success on inducing rats to enter, for the sake of a bait such as fish placed within, and preventing their subsequent escape. They are likely to prove most effective where rats are numerous, and where there are diffuse or indefinite run-ways, as in barns and granaries. The majority of these traps act by means of a trap-door which is so weighted that although it yields easily to the weight of a rat entering from the outside it immediately swings back into position again, and cannot be opened by the movements of rats inside (Figs 8 and 9). Such traps can be used effectively only if rats

are induced to become familiar with them, by obtaining for a few days free access and escape with the trap door fixed in an open position. When it is found that the bait is readily devoured, the

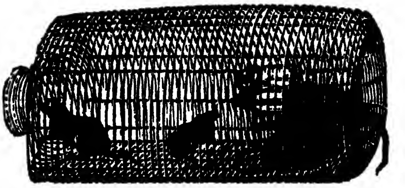

FIG. 8.—Wire-Cage Trap, with Single Entrance Funnel (*Aureuse Model, Paris*).

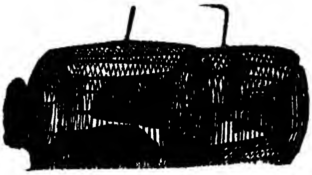

FIG. 9.—Wire-Cage Trap, with Double Entrance Funnel (*Aureuse Model, Paris*).

trap door should be released to its normal position, and a good haul may then be looked for with some certainty. Thereafter, the process of familiarising a new lot of rats must be commenced again. During all these processes the trap should be concealed

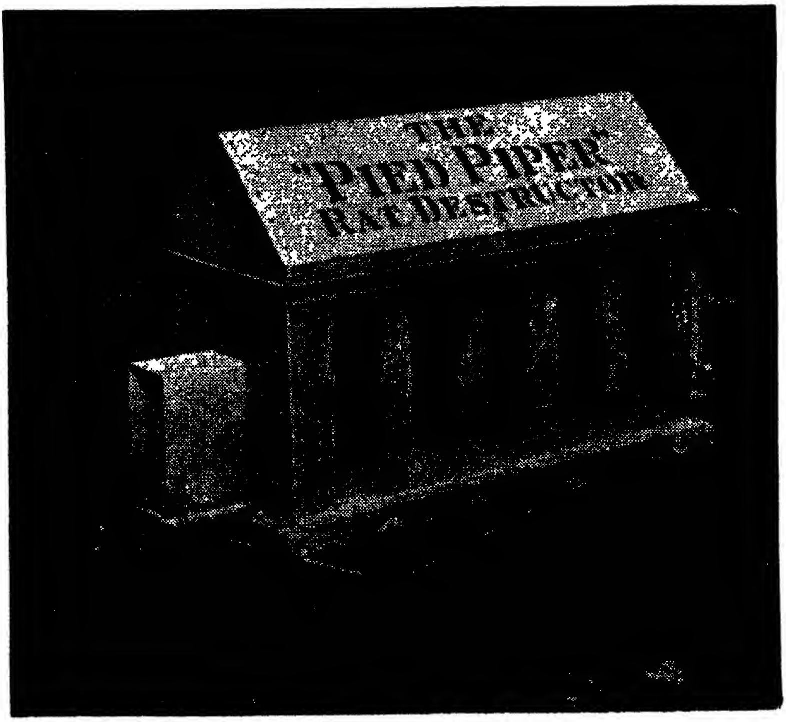

FIG. 10.—Perfected Modification of Cage Trap Type. The "Pied Piper Rat Destructor," showing above, food-container with tunnel in which pivoted chute works, the whole being slightly moved to one side to show, below, the water tank into which the rats are precipitated.

beneath loose straw or any other suitable material, and similar concealment should also be adopted in the case of tunnel traps.

A highly perfected form of the cage trap type, known as the "Pied Piper Rat Destructor," has recently been placed on the

market, and the excellent results it has obtained with proper usage warrant special mention of its merits. This model is a combined feeding trough and automatic rat trap, which may be used in

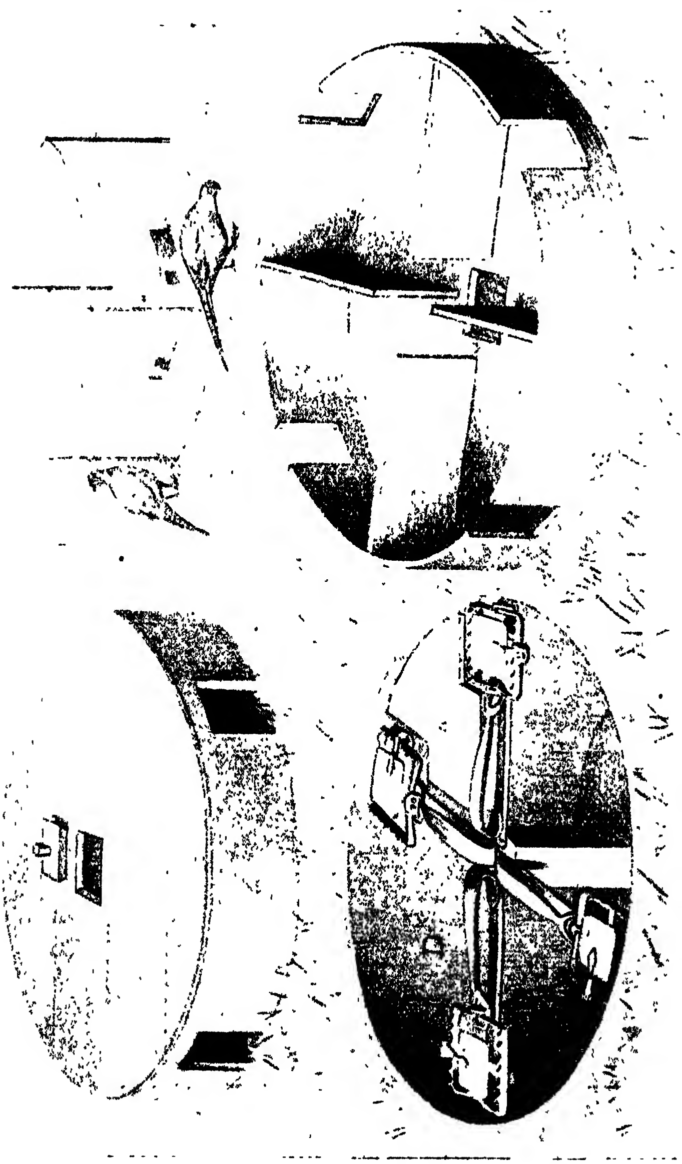

FIG. 11.—DETAILS OF R. SHARPE'S MULTIPLE BATH TRAP.

Top Right Fig.—Trap as set for use, with wire guard for pheasants, etc. *Top Left Fig.*—Nearer view of trap as set, showing lid in cover for placing of bait. *Bottom Left Fig.*—Sunk barrel (emptied of water) with traps set in position. *Bottom Right Fig.*—Under surface of cover. (From R. Sharpe's "Rats, etc.," by courtesy of the Controller of H.M. Stationery Office).

a twofold capacity as a poultry-feeder and trap, or solely as a trap in fields, stack yards, granaries, warehouses, etc. The mechanism of the trap is simple, the essential parts being a covered tunnel which leads to the bait, and the floor of which is a trap door or chute delicately adjusted so that when the rat

passes the centre of gravity it is inevitably precipitated into the water tank, and the chute at once assumes its normal position again. A feature of some importance is the presence of a metal pin, the insertion of which makes the trap door rigid, so that rats may enter and leave with safety until they have become familiar with the apparatus. The simple removal of the pin sets the trap for serious action. Results obtained have been wonderfully good and consistent; eighteen settings of one trap have brought to book as many as 300 rats, each setting having been preceded by a week's baiting, when the rats were allowed free entry and departure to accustom themselves to the presence of the trap.

There are other traps which do not fall into any of the three groups we have just considered. Of these may be mentioned the large cage or stockade, with slide door worked by a human attendant when a number of rats have been attracted within by the bait; the weighted board or old door, also man-controlled, which collapses upon rats feeding beneath; the barrel trap, containing water on the surface of which floating chaff forms a deceitful surface, or with a lid hinged in two sections so that after tipping the rat into the barrel it returns to its former position, or with a simple brown paper cover which, when the rats have become accustomed to its seeming trustworthiness, may be slit to form a series of primitive trap doors. Rather more elaborate is the "Multiple Bath Trap" (Fig. 11), invented by Mr R. Sharpe, the essential parts of which are a barrel sunk in the ground and containing water; a number of traps set just under the surface of the water, and supported on a central pillar and two nails in the barrel, so that when sprung they topple off with their victim into the water; a cover, which guides the rats over the traps; and if necessary a wire cover to prevent the access of domestic animals to the traps. The bait is placed on the central pillar.

Finally, rat trapping by bird-lime is said to be used in Japan, and has been adopted with success in Liverpool and elsewhere; the bird-lime is spread to a depth of rather less than ⅛ inch on a square of cardboard, about 1 foot each way, the centre of which is occupied by bait. The limed tray is placed in the evening in much frequented run-ways, and every few days the skin on the bird-lime must be broken to present a fresh sticky surface. The bird-lime trap is suitable for indoor use only.

THE BIOLOGIST ON THE FARM.—No. X.

PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

University of Aberdeen.

Threadworms of the Soil.—There is great variety in the mode of life among threadworms or nematodes. Some are parasitic in animals, like the threadworm of the horse's intestine, or the gapes-worm of poultry, or the Trichina of rat, pig and man. Some are

parasitic in plants, like the one that causes "ear-cockles" in corn, or those that cause "beet-sickness," "clover-sickness" and so on. Others again live in rotting substances like manure and mouldy paste, or in fluids that have gone bad, as in the case of the "Vinegar-eel." But others live in clean water, and are sometimes so abundant that they give it a peculiar taste! A few are known from the sea, especially among the seaweeds of the shore. Many parasitic threadworms spend part of their life, usually their early youth, in the soil, but there is a large contingent very imperfectly known, that live there permanently. Not in any kind of soil, but usually where there is a considerable quantity of decaying vegetable matter or animal refuse. They seem themselves to be very indifferent to bacteria. They have a tough constitution.

The threadworms of the soil are very like one another,—delicate, translucent or whitish threads, well-deserving their name. They show no hint of rings such as are seen on some minute relatives of the earthworm that are often to be found in damp soil where there is abundant vegetable mould. There is no doubt that we ought to know more about soil-nematodes, and we wish to make reference to some recent work by Richard Menzel.

Many of the soil-nematodes feed on decaying organic particles, and others on the sap of plants into which they bore, but there is a third contingent that have carnivorous habits This was emphasised some years ago by an American specialist on nematodes, Mr N. A. Cobb; and it is confirmed by Menzel's investigations. In the food-canal of representatives of the genera Mononchus, Tripyla and Trilobus, there were found remains of Wheel-Animalcules or Rotifers, Bear-Animalcules or Tardigrades, bristles of earthworms and traces of other nematodes. The interest of the last item is obvious. There are threadworms in the soil that devour other nematodes, *some of which are injurious to root-crops.*

The carnivorous soil-nematodes are strong and agile forms: and the observer was able to watch them, under the microscope, attacking and overcoming other threadworms. He fed some of them on the minute "Vinegar-eels" that swarm in bad vinegar. What Cobb and Menzel have begun should be followed up, for these threads in the web of like are important as well as interesting. It is easy to study living nematodes a little in a watch-glass of water placed under the microscope; their movements are lively and vigorous. The difficulty begins when we try to find out what particular nematode we are looking at. For the specific characters are mostly minute and the literature is not very accessible.

Chicks with Four Legs.—The other day a farmer was kind enough to send me a chick with four legs. Having had a little experience of these monsters, I gave it to a student to dissect, asking him to pay particular attention to the intestinal cæca. In most birds there are two blind tubes growing out from the junction of the small intestine with the large intestine, which is always very short. These blind alleys are often so small, as in pigeons, that they must be regarded as mere vestiges. In other cases, as in

ducks, they are long and of use. The digested food goes up into them and is delayed on its onward passage; the blind tubes or cæca increase the opportunities for food-absorption.

When a chick or other young bird has a supernumerary pair of legs, this may be due to some strand pressing upon the buds that form the embryonic limbs and splitting them into two on each side.

But much more frequently the duplicity goes much further back, namely to the early days when the embryo is simply a disc of cells on the top of the yolk. If, through some dislocation or dissolution of the cells, the germinal disc gets divided into two, the result may be two embryos. They may be likened to Siamese twins. They may be equal in size, or one may be much smaller than the other. There are many gradations between two unequal twins closely joined to one other, and a chick with supernumerary legs. It seems a little difficult to believe it, but there is strong evidence in favour of the view that the supernumerary legs represent an extremely reduced Siamese twin.

This view finds an interesting corroboration in the fact which I have noticed three or four times that the cæca in such cases are three in number instead of two. That is to say, there is a "duplicity" in an internal soft part as well as in the remote hind legs. It was so with the chick which the farmer sent; and one would like to get more instances.

Poison of Ants.—When you disturb a large ant-hill in the wood there is a very distinct and strong scent. That is apparently due to formic acid, which is the commonest poison in ants. It has a toxic and also a corrosive action. But there are many poisonous ants without any formic acid; and the nature of their venom is still uncertain. It may be of an albuminoid nature. There are some ants which do not sting at all, doing nothing but bite. The bite may be painful enough, but it is not in itself poisonous.

When true ants attack white ants or termites they sometimes get an unpleasant surprise. For the soldiers of some kinds of termites are able to squirt a glutinous fluid in the face of small creatures like ants who trouble them, and the douche is fatal. The fluid is contained in a bilobed gland at the sides of the head posteriorly, and it can be squirted out by a median opening at the end of the beak. The squirting is due to the contraction of muscles in the lateral regions of the head. As to the nature of the fluid, it is colourless, viscous and resinous, with an aromatic odour like cedar oil. When an ant gets some of this in its face it rushes about distractedly for a little trying in vain to rub it off, and then it succumbs. There seems no end to the subtleties of thrust and parry in animate nature.

Age and Fertility in Swine.—One of the qualities of living creatures that has been very inadequately studied is fertility. It is of fundamental importance in connection with the breeding of domestic animals, and it would be of great practical value if

more were known of the conditions of its increase or decrease. To a certain extent it is a heritable racial characteristic, as has been proved for man, horses, swine, sheep and poultry. The progeny of a very prolific stock are likely to be prolific. In some cases, *e.g.*, among sheep, it has been practicable by selective breeding to increase the fertility permanently. This implies that fertility is a character that tends to persist, but it is also a variable character. In natural conditions, when the sifting of the struggle for existence is stringent, there may be little variation in the number of the litter or the clutch; in other cases there may be much, as if the number had not yet been defined by selection. Similarly, under man's protecting shield there is often considerable variability within limits.

But although fertility must be regarded as a rather subtle constitutional character, sometimes very difficult to alter, sometimes showing considerable variability, there is no doubt as to its *modifiability*. That is quite different from *variability* of fertility, meaning by variability an inborn capacity for change. The fertility can be influenced temporarily by nutrition and environment, but this modification of the number of offspring produced will not necessarily affect subsequent generations or even the births of subsequent years. It is well known that nutritive stimulation of ewes at the appropriate time will greatly increase the number of twins and triplets. This is an instance of the modifiability of fertility; and there is need for vigorous enquiry here.

But there is another aspect of the modifiability of fertility—when the factors are *internal*, not external. This may be illustrated by the influence of age. Ellinger has recently inquired into the records of the first ten litters of 134 sows of native Danish breed kept in State-supervised breeding centres under uniform conditions and care. All the sows farrowed for the first time at about one year of age. The average of all litters was high, namely 11·5. But the records show an increase in fertility up to a certain point (between the sixth and seventh litter), and then a decrease. To put it in another way, the litter of maximum size was 6·56th in order. Fertility is influenced by age.

Blood-Sucking Fly Larvæ.—We usually, and rightly, think of the larvæ of Muscid flies as scavengers living on decomposing organic matter like carrion. The term "Muscid" includes flies related to the common house fly, *Musca domestica*, such as Bluebottles or Blow-flies, Green-bottles, and even the famous or infamous Tse-Tse fly of Africa. All of them have important "fly-characters" in common, such as having only the first pair of wings well developed, the hind pair, which most insects have well developed, being represented by little quivering "poisers." These Muscid flies all agree in a little trivial feature, that a bristle borne by the feeler or antenna is feathered. A straw shows how the wind blows, and there is often some minute character, like this feathered bristle, that proves the blood relationship of a hundred different kinds or species of animals. A

shibboleth betrays them. A *touch* of common nature proves them all akin. This is one of the most familiar of natural history experiences, and farmers know that an apparently unimportant feature is often an index to a deeply-rooted quality of great value.

In some flies the habits of the maggots are peculiar. There is a Green-bottle fly that lays its eggs amongst the wool of sheep, and the maggots get into the skin and produce bad sores. Another member of the same genus, Lucilia, lays its eggs in the human nostril, and the maggots may pass up to the frontal sinuses and cause great suffering. On the other side of the account there is an Algerian fly, like a house fly, whose larvæ devour the eggs of the dreaded locust. Roubaud has shown that the larvæ of several African blow-flies, which rest on the soil during the day, come up at night and suck the blood of sleeping mammals, such as aard-vark and wart-hog. They cannot complete their development without feeding on the blood of some backboned animal. In some cases they attack man, coming up out of the earthen floor of the hut.

Long ago (1845) the French entomologist, Leon Dufour, discovered that the larvæ of a Green-bottle fly sometimes attack nestling swallows. He noticed that the larvæ were "gorged with blood," and concluded that they were external blood-sucking parasites, not scavengers like most of their kind. Since Dufour's observations similar cases have come to light, and it is plain that we should keep an eye on the habits of Muscid larvæ.

One of the recent cases is reported from San Francisco by O. E. Plath, who found numerous larvæ and pupæ of a particular Blow-fly in nests of goldfinches and Nuttall sparrows, and was able to demonstrate the blood-sucking. Experiments with tame canaries and three other kinds of birds showed that the larvæ were not confined to goldfinches and Nuttall sparrows. The blood is stored by the larvæ in a special crop, and a meal lasts for several days. The blood seems to be essential to the larvæ, for the development is not completed if they do not get their draught. Out of sixty-three nests, representing six species of birds, thirty-nine were found infested by the blood-sucking larvæ. About 5 to 10 per cent. of the nestlings die from loss of blood, and others that become full fledged are seriously weakened. It would be interesting to look into some British nests in this connection.

Starving the Maggots of Flesh Flies.—A Russian naturalist called Ezikov has studied the effect of judiciously starving the maggots of Blow-flies and Flesh-flies, and the result is rather interesting. The starved maggots grow into dwarf flies with a reduced number of ovarian tubes in the ovary. But neither the dwarfing of the fly nor the reduction of its ovaries has any effect on the offspring. In other words, the result of the starving is individual modification, not hereditary change. One of the differences between a worker bee and a queen bee is that the former shows a great reduction in the ovarian tubes. The question arises whether this difference may not be, in part at least, the *individual* result of sparser nurture in the larval period.

One of the most extraordinary of Parasites.—There has been a recent reinvestigation by H. O. Mönnig of a remarkable fluke called *Leucochloridium macrostomum* which is well known on the Continent, but does not seem to have been found in Britain. It lives in the intestine of singing-birds, whence the microscopic eggs are voided on the meadow. They are eaten by a snail—*Succinea putris*—and hatching in the stomach, give rise to active larvæ. An active larva (let us suppose that only one egg was swallowed) bores out of the stomach, and becomes in the body of the snail a relatively large branched body (a sporocyst). The central part of this transformed larva absorbs nutriment from the snail; the branched parts reach the snail's horns and become reproductive. They distend the horns, and bring about the deposition of bands of red and green pigment. Each branch contains eventually over a hundred young flukes (Cercariæ) of the next generation!

The terminal reproductive branches are very muscular, and they pulsate rapidly inside the horns, contracting and expanding sometimes twice a second. If a Blackcap or some similar perching songster is attracted by the snail on a leaf and bites off the agitated horn, the contained bags of larvæ close up automatically at their basis, so that the progeny is not lost. They say that if the bird swallows the tit-bit the result is nil, the parasites are digested. But if the bird gives the tit-bit to its nestling, with weaker digestion, then infection occurs and the cycle begins again. The queer things about parasites are many, but this is one of the queerest.

The Toad's Embrace.—In March and April we have opportunities of observing the male toad's embrace. He grasps the female with such ardour that he sometimes kills her, and he is sometimes seen mounted on a fish. It is a sex-reflex, and if a pole is thrust in below him he grips it so firmly that he can be lifted out of water. At the time of the sex orgasm in March and April there are characteristic excrescences on the backs of the first three digits. There are curious roughnesses, and there is an increased development of skin glands. The change wanes away after the pairing, and the excrescences are practically gone in July. But in August they begin to reappear, and they persist till the following spring. Now it has been recently shown by a Swiss zoologist, K. Ponse, that the embracing reflex and the skin excrescences are due to chemical messengers or hormones which are carried by the blood from the male reproductive organs to the hand. They are both suppressed if the testes are removed, just like antlers. But they reappear if portions of testes are ingrafted beneath the skin!

Bleeding Ticks.—There are leathery ticks, *e.g.*, *Argas reflexus* and *Argas persicus*, which sometimes fasten themselves to the legs of sleeping poultry and draw blood, infecting the birds at the same time with a serious disease. It has been noticed by P. Remy that after a heavy meal these ticks eject blood when they are touched. The blood comes out at the apertures of what are

called the coxal glands, and the theory is that the ejection is a means of relieving the uncomfortable repletion of the tick's alimentary canal after a heavy meal of chicken's blood. What is expelled from the tick's food canal into the general cavity of the body is the watery part of the ingested blood, but in passing this out by the coxal glands some of the tick's own blood has to be sacrificed as well. It seems too clumsy to be quite true.

THE ECONOMICS OF MILK RECORDING.

JAMES WYLLIE, B.SC., N.D.A. (HONS.)

THE essential feature of milk recording, as commonly practised in Great Britain, is the determination of the milk yield of each cow in the herd. In Scotland, the scheme promoted by the Scottish Milk Records Association also comprises the estimation of the average percentage of fat in each cow's milk, but in England the Ministry of Agriculture's scheme makes the testing for fat optional. In neither case, is any systematic attempt made to ascertain the food consumption of each cow, as is done in Denmark, Sweden, the United States of America and elsewhere.

From the economic point of view, no milk recording scheme is complete unless it includes the determination of the total yield of butter-fat as well as of milk. This is easily recognised when the value of the milk depends upon its composition, as in cheese or butter-making; but it is not so generally acknowledged that even where the milk is sold irrespective of its composition, subject to the legal minimum requirements, it is also advisable to know its content of fat, for the reason that, other things being equal, the cost of producing 100 gallons of 4 per cent. milk will be higher than that of an equal quantity of 3 per cent. milk.

The testing for butter-fat, however, and, in a much greater degree, the keeping of individual-cow-records of the foods consumed, involve more labour and expense; hence, it is generally expedient to aim only at records of milk-yield in the initial stages of a milk recording scheme, as has been done in England, and to develop butter-fat and feeding records once the scheme has been firmly established and its advantages made apparent to farmers, as has happened in the United States of America.

The immediate objects of milk recording are two in number, viz.:—

(1) To increase the average milk-yield of the cows in the herd, especially by the elimination of the poorest milkers; and
(2) To obtain better prices for the bulls, cows and calves that are bred for sale, these better prices being a direct consequence of the high milk-yields of the dams and the good milking pedigrees of the sires for, it may be, several generations back.

Under present conditions, when milk records are kept for only a very small percentage of the total cow population, the second

object takes first place in a considerable proportion of "tested" herds, but, as the practice of milk recording spreads, the first object will become of predominating importance since the demand for milk-recorded animals depends to a large extent upon their comparative scarcity.

It may be said, therefore, that the primary object of milk recording is to assist in building up a herd, a breed, a race of cows none of which will give less than 800 gallons of milk in a normal lactation, or whatever other minimum standard may be fixed upon. Underlying this is the proved fact that cows capable of giving high yields of milk, as well as bulls bred from such cows, are able to transmit this character, in greater or less degree, to their progeny; together with the other proved fact that the relative milking capability of a number of cows cannot be accurately measured without the help of milk records.

One general feature of milk recording, which has a distinct bearing upon the economic aspects, is that the results are useful mainly, though not entirely, by comparison, but it is only within certain limits that such comparisons can be validly made. For example, in comparing the milk yields of different cows due allowance must be made for (1) the varying percentage of fat in the different cows' milk; (2) the different conditions as regards climate, housing, feeding, management, etc., under which the cows have been kept; (3) the variation in the month of calving; (4) the varying length of the lactation period, and so on.

The bare statement that an autumn calving cow has given 1000 gallons of 3½ per cent. milk in fifty-two weeks and a spring calver 700 gallons of 4 per cent. milk in thirty-eight weeks does not indicate at all definitely their relative milking capability and gives practically no idea of their relative economic efficiency. A discussion of the procedure which would be necessary before the results from these two cows could be validly compared is beyond the scope of this article,[1] but it is necessary to indicate what is meant by the term "inherent milking capability."

No precise definition is possible, but perhaps the clearest notion of what the term is intended to convey may be got by comparing three cows of the same breed, in the same herd and under the same management. Suppose they have calved at the same time, had exactly the same feeding and been otherwise treated alike. Cow A gives 300 gallons in thirty weeks and then goes dry, Cow B milks for forty-two weeks and gives 450 gallons, whereas Cow C yields 600 gallons in forty-three weeks. One would say that Cow C was a "much better milker" than Cow A, but we cannot yet say how much better. Suppose now that in the following lactation, other things again being equal, the ration is increased by 20 per cent. to each cow, whereupon Cow A gives 320 gallons, Cow B 500 gallons and Cow C 700 gallons, *i.e.*, the poorest milker has responded to the extent of only 20 gallons compared with

[1] *See* Articles by W. Gavin in *Jour. R.A.S.E.* 1912 and in *Jour. Agric. Sci.*, Vol. V., Parts 3 and 4 (June and October 1913).

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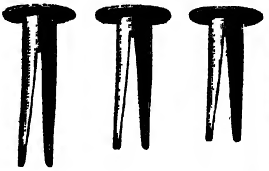

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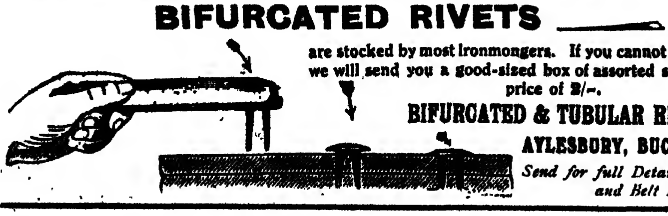

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50 gallons for the moderate and 100 gallons for the best milker. A further addition to the ration would probably have given no further increase in milk from Cow A, only about 20 gallons from Cow B and perhaps 50 gallons from Cow C. These results can be summed up by saying that each cow is inherently capable of giving a certain yield of milk, provided she is supplied with sufficient food-nutrients and is otherwise adequately cared for, but no amount of feeding can force her beyond her inherent capability.

It is now possible to consider more closely some of the economic aspects of milk recording, and it will be admitted that the ultimate object in keeping milk records is to enable the farmer to obtain a larger net financial return from the dairy stock as a whole—not merely to produce cheaper milk. But in order to keep this article within reasonable dimensions it is necessary to limit the discussion to a representative herd kept for milk production, *i.e.*, we shall not deal either with the relations between individual cows in different herds or with those herds which are kept not only for milk production but also, in large measure, for breeding stock for sale. The conclusions arrived at should therefore be considered having regard to these limitations.

One of the commonest and indeed most obvious criticisms of the milk recording schemes in this country is that although they may determine accurately enough the milk yield they do not supply any direct information as to the net profit from each cow in the herd; nor do they provide direct answers to such questions as: Is the "1500-gallon cow" necessarily a better investment, a better rent-payer, than one giving only 1000 gallons? Is it possible to get the same net profit from one 1500-gallon cow as from three cows giving 500 gallons each?

First of all, let us consider the extent to which, in any given herd, the total cost of keeping a cow varies according to her milk yield.

It is commonly assumed or implied (1) that, apart from the extra food consumed, a heavy-milking cow costs no more to keep than a poor milker; and (2) that, apart from the "maintenance diet," the quantity of food nutrients required per cow is exactly in proportion to the milk yield.

As to the first of these assumptions, it must be admitted that a 1000-gallon cow will require and will receive more attention than one giving only 500 gallons, not only in milking, but also in grooming, etc.; she will have a higher capital value and the interest charge must therefore be higher, while a slightly greater charge for management will also be permissible; *i.e.*, although the average cost of these three services for two such cows may be £15 per annum, the former may cost £17 and the latter only £13. Even so the *cost per gallon* would be 6·24d. for the latter and only 4·08d. for the former.

As regards what is commonly known as "depreciation," it is often alleged that heavy milkers do not last the pace so well as

moderate or poor milkers and that they are more prone to digestive and udder troubles, as well as other diseases. On the other hand it is claimed that only a cow with an extra strong constitution and high power of digestion can become a heavy milker. In the nature of things it is difficult to get exact data on such a question, but it may be safely affirmed that, unless heavy-milking cows receive skilful attention, are adequately and systematically fed and are properly housed and milked, they will be liable to deteriorate at an early age.

It must further be kept in view that the use of a high-priced sire, with a "milking" pedigree, involves a higher charge for service than where an ordinary type of bull is kept.

Nothing but harm can, in the long run, be done to the milk recording movement by statements to the effect that the only extra cost for the heavy milker, as compared with the poor milker, is that of the extra food that she will require, or that a cow giving 1500 gallons of milk annually requires no more skilful management—in the widest sense of the term—than one giving only 500 gallons. Nor are such statements necessary if one remembers that an expense of £20 spread over 1200 gallons amounts to only 4d. per gallon whereas £15 over 600 gallons amounts to 6d. per gallon, and that even at 1/- per gallon the extra 600 gallons is worth £30.

Our conclusion under this head, therefore, is that, as regards the costs of production, other than those of the foods consumed, the tendency is for the cost per head to increase as the milk yield increases, but in a much smaller ratio, whereas the cost per gallon tends to decrease as the milk yield increases, though in a somewhat smaller ratio.

The second assumption is more difficult to deal with as it involves the whole question of the economic feeding of milking cows.

The food of a mature cow in calf must be sufficient for two things, viz.:—

(1) To supply the necessary nutrients to maintain her body weight without increase or decrease, *i.e.*, assuming the cow is barren and is neither producing milk nor putting on fat—usually called the *maintenance ration.*

(2) To supply the necessary nutrients (*a*) for the milk which the cow is producing, and (*b*) for the fœtus which she is nourishing—usually called the *production ration.*

This is, of course, the conventional method of looking at the feeding of cows and it naturally leads to the prescription of specific rations for more or less specific conditions; but it is also desirable to bear in mind that the normal cow is dry or "resting" for a period of from eight to twelve weeks before calving, during which period the whole cost of the foods consumed must be borne by the milk produced during the actual period of lactation. The efficiency with which a cow disposes of her food can only be properly

measured by putting the milk produced in a lactation period against the total food consumed in that period *and in the complementary dry period.* Thus it is well known that heavy milkers, even when given as much as they will eat, are apt to "milk themselves down" in condition and must be well fed during the dry period so that they may store up a supply of energy which can be drawn upon in the next lactation, otherwise the milk yield will be adversely affected; whereas moderate or poor milkers generally require only a little more than a bare maintenance diet during the dry period.

As regards the maintenance part of the ration, it is generally assumed that the quantity of food-nutrients[1] required per 1000 lbs. live-weight is the same for all cows whereas—

(1) Small cows of 7 to 8 cwt. require more food for maintenance per 1000 lb. live-weight than large cows of 10 to 11 cwt.;

(2) Cows in high condition require a somewhat better maintenance diet than those in low condition; and

(3) Heavy milkers require more liberal feeding during the dry period than poor milkers—this extra feeding being essentially deferred maintenance.

As stated above, the productive part of the ration has to serve two objects, but for the present purpose attention may be confined to the question of milk production.

What is commonly stated or implied is to the effect that the quantity of food nutrients required for milk production is exactly in proportion to the yield and that, since in a given herd the foods consumed by the different cows will cost about the same per ton, the cost of food will vary in the same degree, *i.e.*, that a cow giving 4 gallons of milk daily on a certain production ration would produce only 2 gallons if that ration were halved. [It is not implied, however, that if a cow gives 2 gallons daily on a certain production ration she will invariably give 4 gallons if that ration be doubled]. All the "feeding standards" for milk cows appear to be based upon this assumption and yet every experienced milk-producer knows that it is valid only within certain limits.

It may be remarked that there is a tendency here to reason in a circle; thus it is said that the food supplied to a cow should be based upon her milk yield while at the same time it is admitted that the milk yield depends to a considerable extent upon the foods supplied. What is really meant is that the milk yield of a cow depends fundamentally upon her inherent milking capability but that this inherent power will not be fully developed unless the machine, in the shape of the cow, is adequately supplied with fuel, in the shape of the foods.

Suppose we have two cows which are in exactly the same

[1] Food-nutrients = digestible proteins + digestible carbohydrates + 2·3 times the digestible fats.

category as regards date of calving, foods consumed, etc., and suppose that one gives 400 and the other 600 gallons of milk within a year (lactation period plus dry period). It is assumed that if the 600-gallon cow had been more heavily fed so that she produced 900 gallons then it would have been found that the production ration had been increased by only 50 per cent., *i.e.*, in the same ratio as the increase in the milk yield. Whether this would have been so or not depends, however, upon the cow's inherent milking capability. If the latter were sufficiently high the desired result would have been obtained; otherwise, it would have been found that an increase of 50 per cent. in the yield would have required an increase of 60 to 80 per cent. in the production ration. On the other hand, an increase of 50 per cent. in the production ration of the 400-gallon cow would probably have resulted in only a very slight increase in the milk yield on account of her low inherent milking capability.

Kellner[1] summed up the matter in these words: "It is shown that *from a certain stage* onwards, the quantity of food required to produce a given increase of milk must be more and more, until finally a point is reached where, in spite of large additions to the ration no extra milk is obtained. If the milk yield is raised by the use of more food, *it is the last quart that requires the most nutriment for its production.*" (Italics are the present writer's).

It follows at once—

(1) That the milk yield produced by a given production ration depends essentially upon the cow's inherent milking capability;

(2) That a high milking capability can be fully exploited only when sufficient food nutrients are provided;

(3) That the increase in the milk yield which will result from an increase in the ration will depend upon the cow's inherent milking capability and the degree to which the latter has already been exploited;

(4) That the milking capability of a young cow cannot be determined beforehand, but only by actual observation.

In the above discussion we have assumed that the "quality" of the food nutrients, *i.e.*, their suitability for milk production, is adjusted to the individual requirements of the different cows in the herd. If it should happen that as the ration is increased its "quality" either improves or deteriorates then the milk yield would be affected accordingly.

Further, as already pointed out, we are not justified in saying that, at a given stage in the lactation of a certain cow, it requires a certain ration to produce a certain milk yield unless we are

[1] "Scientific Feeding of Animals," *Eng. Trans.*, p. 325. *Cf.* M'Candlish, *Feeding of Dairy Cattle*, pp. 85, 172; *Jour. Min. of Agric.*, Feb. 1923, p. 1049.

satisfied that the cow is neither increasing nor decreasing in live-weight.

Another important corollary of Kellner's statement quoted above is—

(5) That the point beyond which it will not pay to increase the milk yield by increased feeding depends upon the relation between the cost of the feeding and the value of the milk. Thus, Kellner's feeding standards for milk cows give two sets of figures—the lower to be used in times of low prices and the higher in times of high prices for milk, compared with the cost of feeding.

With the above conclusions in mind it might be said, therefore, that the secret of financial success in milk production lies in—

(1) The building up of a herd of cows of high inherent milking capability—with the help of milk records, etc.;
(2) The feeding of each cow up to her limit of profitable production, *i.e.*, until the cost of the extra food exceeds the value of the extra milk produced [1]—again with the help of milk records; and
(3) The possession by the farmer of the necessary skill, knowledge and experience.

So far only the yield of milk has been considered, but in reality the quantity of food nutrients required per gallon varies also according to the percentage of dry matter or "total solids" in the milk. Extensive investigations by Swedish workers have shown (1) that a given quantity of butter-fat can be produced more cheaply in "rich" than in "poor" milk, *e.g.*, it was found that with 3 per cent. milk about 22½ food units are necessary per kilogram (2·2 lb.) of butter-fat compared with only about 18 food units in the case of 4 per cent. milk; (2) that an increase of 1 per cent. in the percentage of fat corresponds to an increase of fully 6 food units per 100 kilograms (22 gallons) of milk, so that with butter at 1s. per lb. an increase of fat worth about 2s. 5d. could be produced at a cost of about 9¼d.

This emphasises, of course, the desirability of measuring the yield both of milk and of butter-fat. It follows that where the milk is paid for on the basis of its fat-content, rich milk can be more economically produced than poor milk, especially when it is remembered that the percentage of total solids does not generally increase to the same extent as that of fat—always provided the increase in fat-content is not accompanied by a decrease in the milk yield; but where the milk is sold irrespective of its composition, beyond a certain minimum standard, rich milk will be less profitable than poor.

It should now be abundantly clear that if they are to be of maximum value, systematic milk records (of both quantity and "quality") must be accompanied by systematic feeding, based

[1] This pre-supposes a fixed number of cows. A full discussion of all that is here involved is beyond the scope of this article.

upon the inherent milking capability of each cow. The usual method is to give all the cows in milk the same basal ration sufficient for maintenance and, say, one gallon of milk, and thereafter to ration each cow roughly according to her milk yield, always bearing in mind (1) that it is only by gradually increasing the ration that we can discover how much milk a cow is capable of giving; (2) that we must consider not only the immediate effects of the ration upon the milk yield, but also its ultimate effects upon the body-weight, health and constitution of the cow, the milk yield of the subsequent lactations, etc., and (3) that the object must be to feed each cow up to the limit of the most profitable production: we must take into account not only an increase in the yield, caused by an increase in the ration, but also what it is worth and what it has cost to produce.

Now let us consider the relation between the net profit and the milk yield per cow per annum, taking first of all the simplest possible case.

Let us suppose that all the cows in the herd calve during the months of February and March. We can assume that the average prices per unit for food nutrients, labour, etc., will be about the same for each cow, and we shall further assume, in the meantime, that the milk produced by each cow will sell at the same average price per gallon, *i.e.*, we have eliminated two important variables, and can now make a direct comparison between the quantity of food nutrients consumed by and the total milk-yield from each cow. Do these vary in exactly the same ratio?

We have seen above that under such conditions the cost of the maintenance ration and of labour, depreciation, bull service, general expenses, interest and management will generally be somewhat higher per head, but considerably lower per gallon for the heavy than for the light milkers. What about the production ration?

If the farmer has been completely successful in adjusting the production ration of each cow according to her inherent milking capability, then the cost per gallon on this account will be the same for each cow *whatever her milk yield*; but if we bear in mind that the milk yield will be in direct proportion to the production ration only up to a certain point, and that this point will be reached much sooner with light than with heavy milkers, we shall probably be safe in concluding that the former are likely to be more or less "over-fed," and the latter more or less "under-fed"—in relation to the milk yield, *i.e.*, the quantity (and the cost) of the food nutrients required per gallon of milk will be likely to decrease gradually as the milk-yield rises. As between two cows, each of which has given 1000 gallons, the deciding factor will be their relative inherent milking capability: the higher this power the lower will be the quantity of food nutrients required per gallon—assuming equality in the fat content.

The practical significance of this case is that, even when the very highest skill is exercised in feeding, the cost per gallon tends to fall and the net profit per cow to rise as the milk yield increases;

and that still more advantageous results are likely to accrue from heavy milkers because of the fact that it is never possible to co-ordinate exactly the feeding of the cow and her milking capability.

In applying this conclusion, however, it must be borne in mind that such a simple case seldom occurs in practice. For one thing, we must take into account the variation in the fat-content of the different cows' milk and its effect upon the quantity of food nutrients required per gallon as well as upon its value; for another, the average price per gallon will not be exactly the same for each cow's milk because of the variation in the proportion of the total yield which is produced during the months of highest prices for milk.

If now we pass to the more usual case, where the cows calve at different times throughout the year, several complications are introduced. For example, it is clear that an autumn calver giving 700 gallons is not necessarily a more profitable cow than a spring calver giving 650 gallons. The milk of the former will be worth more—on account of the greater yield and the higher average selling price—but it will cost more to produce than that of the latter. In other words, we have now four variables, viz.:—(1) The unit prices of the food nutrients; (2) the quantity of food nutrients required per gallon of milk (or pound of butter-fat); (3) the yield of milk (or of butter-fat); and (4) the average price per gallon of milk (or per pound of butter-fat).

It would appear, therefore, that even in a given herd the milk-yield per cow is not invariably a reliable measure of the net profit per cow per annum, and that the latter can only be found by taking into account not only the milk yield but also the cost per gallon and the value of the product.[1]

In conclusion, brief reference may be made to two questions which arise out of the foregoing discussion, viz.:—(1) Is it possible to ascertain the net profit from each cow in the herd, and (2) would this information be of any practical utility if it were available, or at least would its value justify the effort involved in getting it?

The latter question may be first dealt with, since, unless it can be answered in the affirmative, the former question is scarcely worth discussing.

In so far as milk recording aims at providing a basis upon which to build up a more productive herd, and so long as we compare cows that are in the same category as regards time of calving, age, etc., then it would appear that the milk yield affords a fairly safe guide for selection.

If we admit, however, that the ultimate object of milk-recording is to enable the farmer to secure the maximum possible total net profit from the herd, then it becomes a question whether the milk-yield provides a reliable basis for determining whether autumn or spring calvers are the more profitable, whether high yields

[1] *Cf.* Article on "Milk Yields, Costs per Gallon and Financial Results," in this *Journal* for October 1922.

obtained by heavy feeding are more profitable than somewhat lower yields obtained by more moderate feeding, whether it pays better to select for high milk-yields and low fat-content or for moderate yields and high fat-content, and so on. For example, if it could be demonstrated that cows calving in the autumn are at least as profitable as those calving in the spring we should have gone a long way towards showing how the "surplus" production of the late spring and early summer months could be obviated.

Further, complete records for each cow would afford a conclusive answer to the criticism that very high milk-yields are generally obtained only by an uneconomic expenditure on foods, labour, depreciation, etc. Above all, they would undoubtedly clinch the argument that *the most profitable cows are those which have a highly developed milking capability, and which are fed only up to the limit of profitable production.* The cost per gallon of the milk of a 1000-gallon cow may be very little less than that of a 500-gallon cow, but the former has an overwhelming advantage in the turnover: 1000 gallons of milk at a profit of 4d. per gallon amounts to £16, 13s. 4d., 500 gallons at 3½d. to only £7, 5s. 10d. In short, it is only through the agency of complete cow records that the economic advantages of milk recording can be fully demonstrated and the economics of milk production thoroughly investigated.

Now let us ask: Is it possible to obtain reliable, not to say mathematically accurate, complete records for each cow in the herd?

One might answer, in the first place, that since it has been found both possible and practicable in the United States of America, Denmark and elsewhere it should also be possible and practicable to obtain such records in Great Britain. At the same time it is well to bear in mind that in the countries referred to the dairy herds are smaller than they are in this country, while the feeding, milking, etc., is done to a greater extent by the farmer and his family.

The fact remains that if it be possible to feed the cows "according to their milk yield," as is widely advocated in this country, it should also be possible, with a little extra effort, to record the foods actually fed; and it is, of course, the recording of the foods consumed which is the chief stumbling-block in such a scheme. Numerous difficulties will be encountered, *e.g.*, in connection with the apportionment of the charge for grazing, but in general these appear more formidable than they actually are: it is beyond the scope of this article to discuss them in any detail.

It is not suggested that every farmer who keeps milk-records will find it practicable to keep complete cow-records for all the cows in the herd, but the writer is convinced that the milk-recording movement in this country would receive a distinct fillip if authentic data, showing the relation between the milk-yield and the net profit from each cow in each of a number of representative herds, could be produced.

THE STOMACH WORM OF SHEEP, CATTLE AND OTHER ANIMALS.

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THERE is a disease of sheep and goats seen in Scotland and other countries which, caused by the so-called "Stomach Worm," is responsible for considerable loss to farmers throughout the world. These worms cause general unthriftiness when present in large numbers. This is due mainly to the poor condition of the blood caused partly through the production of a special poison by the worms, partly by interference with the digestive functions of the stomach, and partly through actual loss of blood. It is possible also that the small perforation left at their point of attachment may be the starting point for some bacterial infection. The onset of the symptoms is generally gradual. There is no fever; but dullness and unthriftiness are obvious, and diarrhœa may be present. These symptoms are accompanied by paleness of the membranes of the eyes and mouth. Frequently the hanging parts—the abdomen, the space under the jaw and so on—show a watery swelling. The emaciation is progressive and, if badly infected, the sheep finally dies.

The presence of the worms can be demonstrated by examining the droppings. Another good method is to kill and open an

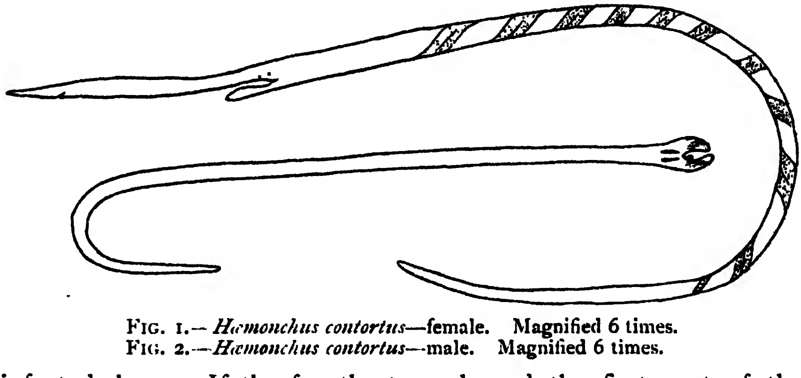

FIG. 1.—*Hæmonchus contortus*—female. Magnified 6 times.
FIG. 2.—*Hæmonchus contortus*—male. Magnified 6 times.

infected sheep. If the fourth stomach and the first part of the intestine be examined, a wriggly mass of small red worms will be seen. Some will be attached to the wall and some free in the cavity. On closer examination small droplets of blood may be observed on the stomach wall, showing where the worms had been attached.

This worm, although attacking cattle and goats, is of greatest importance as a parasite of sheep. It is especially serious in warm, moist countries; but it is present in Scotland and other temperate lands where, during warm summers and on overstocked permanent pastures, it is capable of doing considerable damage.

The parasite, sometimes called the "Wire-worm," is known to science as *Hæmonchus contortus*. Like those of the Hook-worm, the

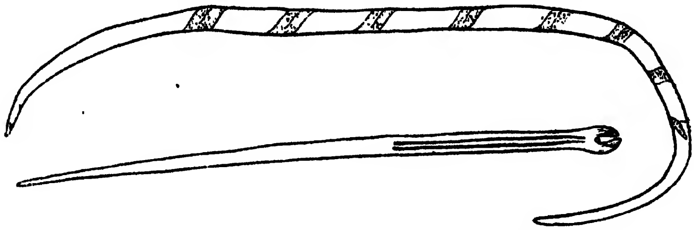

FIG. 3.—*Mecistocirrus digitatus*—female. Magnified 6 times.
FIG. 4.—*Mecistocirrus digitatus*—male. Magnified 6 times.

sexes are separate. The female (Fig. 1) is about an inch long, and when alive is red in colour. It is pointed at both ends. The male is shorter and thinner (Fig. 2) than the female. The posterior end of the body has a "bursa" as in the Hook-worm; but unlike it, this bursa is divided into two lobes. Two short brown "spicules" can be easily seen with a hand lens just in front of the bursa. In both sexes the head end is thin and tapering, and when examined under the microscope, it is found that there is no rigid mouth capsule as in the Hook-worm. There is present, however, a strong tooth used for attachment to the lining of the stomach wall (Fig. 6).

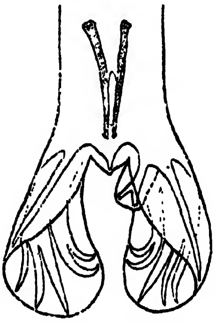

FIG. 5.—*Hæmonchus contortus*—"bursa" of male. Highly magnified.

The distribution of *Hæmonchus contortus* is world wide wherever sheep, goats and cattle are found. It is most important in warm, moist low-lying country, and less so in cold, dry or high lands.

Life History.—The female produces thousands of very small eggs which pass out with the droppings. Under warm, moist conditions these eggs may hatch in a few hours. However, in Scotland, hatching would require a number of days or even weeks. A small "larva" emerges from the egg, and after growing and moulting, becomes an infective larva. Until this stage is reached—a matter of days or weeks—it cannot infect a sheep. In its infective stage it is very resistant to cold and drying and may live for nearly a year. On moist dull days the larvæ climb up blades of grass. Below 40° F. and in very dry weather, while not dead, they remain motionless; but as soon as the weather becomes warm or moist again, the larvæ resume their activity. When swallowed by a ruminant, they complete their development. The

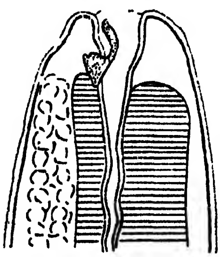

FIG. 6.—*Hæmonchus contortus*—head end, showing "tooth." Highly magnified.

length of life in the sheep is unknown, but may be at least a year and a half. It is obvious, therefore, that if infected sheep are kept on permanent pastures they are continually dropping eggs, which hatch and give rise to larvæ that reach an infective stage and are swallowed. The infection may thus, from a very small beginning, become exceedingly acute.

Treatment.—Fortunately a satisfactory treatment has been found for this disease. This consists of the administration of a mixture of sodium arsenite and copper sulphate dissolved in water. It is most important to realise that these substances are very poisonous, and must only be administered in suitable doses and with the greatest care. It is very undesirable to attempt treatment without qualified advice. If only a few sheep have to be dosed, an enamel funnel attached to a length of rubber tubing ending in a short piece of metal tubing, is a very useful device. The solution is accurately measured, the metal tube is placed in the sheep's mouth—the head being held level—and the liquid is slowly poured in. Treatment to be effective must be prompt. Good results cannot be expected in advanced cases.

Prevention.—The parasite not only infects young stock more easily than adults, but produces more severe symptoms in them. Moreover, the worms interfere with growth and so lead to stunted adults—a condition which can never be improved. Accordingly, steps should be taken to prevent lambs becoming infected and the cleanest pasture provided for them. Hill pasture is safer than low-lying meadows.

Infection comes only from the droppings of infected sheep, and the young infective stage of the parasite can live in the soil and grass for about a year. Obviously the longer the sheep are on the same piece of land, the heavier the infection becomes. This danger from *permanent* pastures is present in *all* worm diseases.

Several methods of prevention based on these observations may be suggested.

Sheep may be dosed in the autumn just before the cold weather starts, and at once removed to clean pasture for the winter. They may be dosed again if examination of the droppings shows that the stock is not yet free of the worms. The old pasture meanwhile should be ploughed up and resown, or allowed to lie fallow for a year when it will be again safe. This plan ensures that at lambing the flock is reasonably free from the parasites.

Another plan is to dose the flock *monthly* with sodium arsenite and copper sulphate. This kills all the parasites in the sheep. The infective stages are swallowed and killed by the next monthly dose before they can become mature and lay eggs. By this means no new larvæ can hatch out, and all the existing larvæ are gradually killed off. This plan requires some time and trouble, but it is very effective.

There is only one other worm which resembles this parasite.

This is called *Mecistocirrus digitatus*, which, though only recorded from Asia so far, is probably more widely distributed. This worm resembles *Hæmonchus contortus* very much in its naked-eye appearance, and as it also occurs in the stomach, an infrequent place to find parasites, it must frequently have been mistaken for it in the past. It has the same colour, the same "toothed" mouth-end, the same spiral appearance in the female, and the same double lobed type of bursa in the male. It can be distinguished from *Hæmonchus*, however, by the absence of the flap covering the genital opening in the female (Fig. 3), and by the presence of very long spicules in the male (Fig. 4). It is important that this distinction should be made, as we know little of the distribution of *Mecistocirrus* and nothing at all of its life history; whereas the life history of *Hæmonchus* has been worked out by Veglia, Ransom, and others in great detail. It is only on a knowledge of the life history that preventive measures can be adopted. Accordingly, facts as to the distribution of *Mecistocirrus*, and fresh specimens of it, are of the greatest importance to workers on the subject. The fact that the pathology in both cases seems to be the same, increases the need for information.

It should be remembered that cattle and goats, while not showing such severe symptoms as a rule, can carry the infection. Deer also may harbour the parasite. Horses, on the other hand, are apparently not susceptible. Both worms mentioned above have been reported once from man; but it is very doubtful if they really are human parasites, and possibly some mistake has been made.

JOINT ILL IN FOALS.

WM. BROWN, M.R.C.V.S.

Marischal College, Aberdeen.

THE Scientific Committee, appointed by the Clydesdale Horse Society, to investigate the disease known as Joint (Navel) Ill in foals, have recently issued their Report to the Society. It is mostly of a scientific character, but there are certain practical features of importance.

The Committee at the outset issued cards of inquiry in order to ascertain the general conditions under which the disease occurred, and to obtain other general information. The information derived from these cards was not of great value, and there did not appear to be any special condition which could be looked upon as a predisposing cause of the disease. Foals born under the best possible hygienic conditions contracted the disease as readily as those which received no special care. Foals which were born in the grass field became victims as frequently as those born in a foaling box. It was noted, however, that foals which became affected were usually carried for a rather shorter period of gestation than usual.

The Committee were fortunate in securing the services of Dr R. M. Buchanan, bacteriologist for the City of Glasgow, to carry out the bacteriological part of the investigation, and at first special attention was directed to two points:—

(1) Whether there is one disease called Joint Ill, or whether several specific diseases may not be included under that one designation.

(2) Whether there is such a thing as infection before birth.

In all, thirty-four affected foals were more or less completely examined from the pathological and bacteriological standpoint, and five mares. The date of appearance of the first symptoms varied from "the time of birth" to the twenty-fourth day; on the average the symptoms appeared on the fourth or fifth day. The duration of the illness lasted from one to thirty days, the average being eight days. The first symptom was usually the swelling of a joint, or joints, but in a percentage of cases the foal was sickly from birth, and occasionally no joint symptoms were manifested. The joint lesions were rather more frequent in the hind than in the fore limbs, and the hock and the knee were the joints most commonly attacked. The details of the cases examined show that most of the internal organs may be more or less affected. In several of the cases the navel cord had been ruptured at birth, and in the others it had been ligatured and cut, but these different conditions had no effect on the onset or on the course of the disease. In the great majority of the cases, however, a probe could be passed through the navel after death, showing that healing had not taken place. In some of these cases part of the urine had been escaping through this opening. This condition was noted to be more common in colt than in filly foals. The navel part was, therefore, obviously a septic centre from which infection could spread through the body.

The relationship between contagious abortion in mares and joint ill is an open question, but as far as the inquiry went there was no apparent relationship between them. An analogy is drawn between this disease and septic infection of the navel in the human subject, which was so common before the days of antiseptics but which has now disappeared.

Portal of Infection.—The gelatinous navel cord affords an excellent medium for the development of micro-organisms with which it may become contaminated during birth or after the foal is born. The thick but soft walls make it difficult to close completely the navel stump by ligature. In all the cases examined the infection had apparently entered by the navel, and had spread along the vessels whose broken ends terminate at this point, and had ultimately gained entrance to the general circulation.

The Cause of the Disease.—Early in the course of the investigation Dr Buchanan isolated a micro-organism in the form of a streptococcus from the diseased parts of affected foals. When inoculated into healthy foals this organism reproduced the disease, and he afterwards showed that it was the causal agent in the

greater proportion of the cases examined. A minute description of this streptococcus is given in the Report. Dr Buchanan was also able to isolate a similar micro-organism from the genital tract of mares which had given birth to affected foals. This is a point of great importance. Later in the investigation another type of organism was isolated from a smaller percentage of the cases. It was in the form of a bacillus, and belonged to the colon group, and was ultimately shown to be the causal agent in these cases. It will be necessary to take this organism into account in the preparation of materials for preventive use in the future.

Dr Buchanan, therefore concludes that Joint Ill is caused by two different types of organisms, one a streptococcus and the other a type of *Bacillus coli.* The main difference in the symptoms produced by these different organisms is, that cases due to infection by the streptococcus are longer in developing, and joint lesions are nearly always the prominent feature, while those caused by the *Bacillus coli* develop very soon after birth, and run a very rapid course, with symptoms resembling generalised blood-poisoning. Foals affected with this latter type of the disease frequently show no joint symptoms at all, and death often occurs within two days.

On one occasion a microbe called *Bacillus nephriditis equi* was isolated from the lesions; this organism has occasionally been isolated by other investigators.

Source of Infection.—Various opinions were previously held regarding the source of infection. The original belief was that the disease was contracted from infected surroundings, especially the foaling box. In later years the genital tract of the dam was considered to be the infective centre, while some held the view that the foal's intestine was a probable route. During the investigation all these opinions were kept in view, and there were strong indications that, in the majority of cases, the genital tract of the mare was the immediate source of infection where this was caused by the streptococcus, while the infection in the bacillary form was derived either from the genital tract of the mare, or from contaminated surroundings after birth. It was also considered that the sire might play an important role in the transmission of the disease.

Time of Infection.—The second purpose of the inquiry was to ascertain, if possible, whether infection takes place before birth, and the evidence tended to show that it occurs in the genital tract during delivery, or from contaminated surroundings after birth. The finding of organisms in the vagina of the dam similar to those found in the joints of the affected foal indicates that the sire is a possible carrier of the disease from one mare to another.

Treatment.—When Dr Buchanan had isolated these organisms from affected foals and establised their connection with the disease, the Committee approached Mr J. B. Buxton, F.R.C.V.S., Veterinary Superintendent to the Wellcome Physiological Research Laboratories, Beckenham, and he very kindly consented to prepare a vaccine, and a serum from the causal streptococcus, and these

products were used in order to test their efficacy during three successive seasons. During the first year these products were used mostly on affected foals for curative purposes, but neither the vaccine nor the serum proved of any value as curative agents except in very mild cases. This result was anticipated beforehand, because, usually, the disease is so generalised in the system of the foal before symptoms appear that there is little likelihood of any substance being able to check its progress.

Attention was then directed to the prevention of the disease by treating the mare before foaling, and also the foal at birth before symptoms had time to appear. Mares with a bad history were mostly chosen for this purpose, and three types of experiment were carried out—

(1) Mares received three injections of the vaccine at weekly intervals, the last being given at least a month before foaling.

(2) Mares received one or two doses of serum at a weekly interval, the last being given at least a fortnight before foaling.

(3) Foals from these dams received a dose of serum within twenty-four hours after birth. The serum was also used on foals from affected dams which had not previously received any treatment.

The vaccine and serum were prepared by the ordinary methods adopted for the preparation of these materials, and the conclusions arrived at were, that the best results were obtained by treating the mares before foaling, particularly with a series of three injections of vaccine, the last injection being given at least a month before foaling, and giving the foal a dose of serum within twenty-four hours after birth. Where the mares were treated with serum the results were not so satisfactory as with vaccine.

During the second season the death rate amongst foals from previously affected dams—that is, mares with a bad history, some having had three dead foals in succession—was 17 per cent. This figure was considered too high, and in the following year the materials were considerably strengthened, with the result that the death rate amongst foals from similar mares was reduced to 4 per cent. The reduction in the percentage of mortality is significant.

No system of treatment is perfect, though the public expect it to be so. The weakling will go under whatever methods are adopted. As, in the experiments referred to, prevention against the bacillary type of infection was not provided for, a few would die from this particular form. Mr Buxton tested a number of samples of blood from mares which had given birth to affected foals, and found that the blood gave a positive test to the specific microbe in a large percentage of cases.

The recommendations arising out of the results of the investigation are given as follows:—

(1) "That the hygienic precautions hitherto recommended should be more universally and strictly carried out.

(2) "That in the case of mares whose foals develop the disease before the 'foal heat,' service should be delayed, and the genital passage frequently irrigated with an antiseptic solution.

(3) "That, in the case of the stallion, antiseptic precautions should be taken to prevent him from acting as a possible carrier of the infection.

(4) "That protective vaccination of pregnant mares should be practised."

The antiseptic treatment of the genital tract of the mare is of great importance. A weak solution of an antiseptic should be injected with a syringe twice daily from the time that the disease has become apparent in the foal until within two or three days of service. A very useful non-irritant antiseptic is Condy's Fluid, one part in forty parts of water.

I.—Export of Seed and Ware to England.

Wart Disease of Potatoes Regulations.

In consequence of the issue by the Ministry of Agriculture and Fisheries of a new Wart Disease of Potatoes Order, which took effect on 1st June 1923, it is important that farmers and merchants in Scotland who send potatoes (either seed or ware) to England should make themselves acquainted with the requirements of the Ministry's regulations so far as they affect the introduction into England of Scottish grown crops. The following is a summary of the Ministry's requirements:—

(1) *Seed Potatoes.*—(*a*) Seed potatoes from crops of the "immune" varieties which have been inspected under the Board's scheme during the growing season, and certified by the Board to be of a purity of not less than 99·5 per cent. may be sent to any part of England and Wales.

[In future the numbers of the certificates issued by the Board for this class of seed potatoes will be prefixed by the letters T. S. (denoting True Stocks) instead of the letters I. V.]

It should be noted, however, that no potatoes grown on infected land may be sold for planting purposes except under the conditions of a licence granted by the Board.

(*b*) With regard to seed potatoes from crops of (i.) susceptible varieties, and (ii.) immune varieties not certified as to purity, the Ministry make a distinction between crops grown outside the Scottish "Infected Areas" and crops grown within those areas.

For crops grown outside the "Infected Areas" the Board's certificate will be to the effect that the land on which the potatoes were grown is outwith an "Infected Area," and more than a mile from the nearest case of wart disease.

In the other case the certificate must show that the potatoes were grown within an "Infected Area," and more than a mile from the nearest case of wart disease; and that the crop from which

the potatoes were taken was inspected by the Board's staff and no wart disease found.

[The numbers of the certificates issued by the Board for these two classes of seed potatoes will in future be prefixed by the letters C. L. (denoting Clean Land) instead of the letters P. E.].

The numbers of the relative certificates must be quoted on the occasion of the sale of any seed potatoes to England.

(2) *Ware Potatoes.*—No restriction is placed on the admission into England of ware potatoes grown in Scotland, except in the case of potatoes of the non-immune varieties grown on land situated within a Scottish "Infected Area." These cannot be sent to the clean areas in England unless the importer has received from the seller in Scotland a statement to the effect that the crop from which the potatoes were taken was inspected by an officer of the Board and no wart disease found.

II.—Inspection of Crops and Certification by Board of Agriculture for Scotland.

The Board have made complete arrangements for the inspection of this season's crops for the purpose of enabling farmers and merchants to comply with the new regulations governing the export of potatoes to England. Particulars of the Board's scheme for this purpose have already been published and communicated direct to growers and the trade.

With regard to the certification of crops it may be explained that the new system referred to in Section I. above has been adopted in consultation with the Ministry of Agriculture and Fisheries with a view to having a uniform system of certification in operation in England and Scotland.

III.—Amendment of the Regulations for the Control of Wart Disease in Scotland.

The additional restrictions imposed by the new Order of the Ministry of Agriculture and Fisheries on the introduction into England and Wales of Scottish grown crops, have rendered it necessary for the Board in the interests of Scottish agriculture to withdraw the Wart Disease of Potatoes (Scotland) Order of 1918 and to substitute therefor the Order of 1923 which took effect on 1st July.

The Order of 1918 was made as a result of the experience gained in the administration of the Wart Disease of Potatoes (Scotland) Order of 1913 which had shown (1) that the spread of wart disease is caused more by the growing of potatoes in gardens and allotments than on farms, and (2) that a system of control of each individual case of the disease is not effective in checking the rapid spread of wart disease in gardens and allotments.

Under the Order of 1918 certain districts were scheduled as "infected areas." The scheduled districts comprised the whole of the counties of Clackmannan and Kinross, and portions of other counties. Within these districts all occupiers of gardens and allotments, etc., not exceeding half an acre in extent were prohibited from planting potatoes except those of varieties approved by the

Board as immune from wart disease. Experience has shown that the spread of wart disease in gardens and from gardens to adjoining agricultural land has by this means been effectively checked. Unfortunately, however, the disease has continued to spread in gardens and allotments in some districts outside the "infected areas."

The Board accordingly came to the conclusion that the restriction imposed by the 1918 Order on the planting of potatoes in small gardens and allotments within the "infected areas" should now be applied to all gardens and to pieces of land not exceeding half an acre throughout Scotland.

Before arriving at this conclusion the Board convened a meeting on 16th March 1923, of representatives of the Scottish National Union of Allotment Holders, the Association of County Councils in Scotland and the Convention of Royal Burghs. At this conference the delegates without exception expressed, on behalf of their organisations, complete approval of the Board's proposals to limit all holders of land not exceeding half an acre, as well as holders of private gardens, to the planting of only immune varieties of potatoes.

Briefly the Wart Disease of Potatoes (Scotland) Order 1923, which is now in force provides that:—

(1) Except with the authority of the Board all occupiers in Scotland of pieces of land not exceeding half an acre and all occupiers of private gardens, whatever the area, will be prohibited from planting any but immune varieties of potatoes.

> *N.B.*—Hitherto this restriction, so far as non-infected land was concerned, applied only to gardens, plots, etc., of half an acre or less in those areas which the Board had scheduled as "infected areas" for the purposes of the Order of 1918. Some gardens had also been scheduled because of their proximity to infected land.

The Board do not consider that this restriction will cause hardship to the small grower. Except, perhaps, in the case of first-early varieties, there is a wide selection of good quality immune varieties and ample supplies of "seed" are available. With a view to meeting the situation as regards first-earlies, the provision contained in the 1918 Order by which a licence may be obtained for the purpose of growing a susceptible first-early variety is retained in the new Order.

(2) Although, as in the 1918 Order, certain districts will be scheduled under the proposed Order as "infected areas" no special restrictions will be applied by the Board to these areas. The scheduling will be solely for the purposes of the Orders made by the Ministry of Agriculture and Fisheries and the Irish Departments governing the entry of Scottish-grown potatoes into England and Wales and Ireland. The new Order of the Ministry already referred to will impose special restrictions on the movement of potatoes grown in the districts of Scotland which are scheduled by the Board as "infected areas," while the regulations governing the entry of Scottish-grown potatoes into Northern Ireland and the Irish Free State entirely prohibit the importation of potatoes grown in such districts.

In the circumstances, it has been considered unjust to retain as "infected areas" in the new Order several parishes presently scheduled which are either free or nearly free from wart disease. Many of these parishes were scheduled by the Board. in 1918 merely as a precautionary measure, and, in terms of the 1918 Order, the scheduling did not impose any restrictions on potato growing on non-infected land other than half acre plots. On the other hand, it has been considered necessary to include in the new schedule several parishes in Fife and Midlothian, and also a large number of burghs throughout the country. This is due to the development of the disease in those areas since the 1918 Order was framed. The revised list of "infected areas" is as follows :—

The City of Edinburgh, with the exception of the municipal wards of Cramond and Corstorphine.

The City of Glasgow.

County of *Argyll:* the police Burgh of Lochgilphead.

County of *Ayr:* the civil parishes of Ardrossan, Dreghorn, Dundonald, Irvine, Kilmarnock, Kilmaurs, Kilwinning, Largs, Monkton and Prestwick, Riccarton, Stevenston, Tarbolton and West Kilbride, the municipal Burghs of Ayr, Irvine and Kilmarnock, and the police Burghs of Darvel, Galston, Newmilns and Greenholm, Prestwick and Stewarton.

County of *Bute:* the civil parish of Kilbride, the municipal Burgh of Rothesay and the police Burgh of Millport.

County of *Clackmannan.*

County of *Dumbarton:* the civil parishes of Bonhill, Cardross, Cumbernauld, Kirkintilloch, New Kilpatrick and Old Kilpatrick, and the municipal Burgh of Dumbarton.

County of *Dumfries:* the civil parish of Langholm, the municipal Burghs of Dumfries and Sanquhar, and the police Burghs of Lockerbie and Moffat.

County of *Fife:* the civil parishes of Auchtermuchty, Culross, Falkland, Strathmiglo and Tulliallan, the municipal Burghs of Auchtermuchty, Cupar, Dunfermline and Falkland, and the police Burgh of Leslie.

County of *Kinross:* the civil parishes of Kinross and Orwell and the police Burgh of Kinross.

County of *Kirkcudbright:* the police Burghs of Dalbeattie and Maxwelltown.

County of *Lanark:* the civil parishes of Blantyre, Bothwell, Cadder, Cambuslang, Glasgow (Landward), Hamilton (Landward), New Monkland, Old Monkland and Rutherglen, and the municipal Burghs of Airdrie, Coatbridge, Hamilton, Motherwell and Rutherglen.

County of *Linlithgow:* the civil parish of Uphall, the municipal Burgh of Linlithgow, and the police Burghs of Bathgate and Bo'ness.

County of *Midlothian:* the civil parishes of Currie, Inveresk, Lasswade and Newton, the municipal Burgh of Musselburgh, and the police Burgh of Penicuik.

County of *Peebles:* the municipal Burgh of Peebles and the police Burgh of Innerleithen.

County of *Perth:* the municipal Burgh of Perth and the police Burghs of Auchterarder, Callander, Crieff, Doune and Dunblane.

County of *Renfrew:* the civil parishes of Abbey (Paisley), Erskine, Inchinnan and Renfrew, the municipal Burghs of Greenock, Paisley, Port Glasgow and Renfrew, and the police Burghs of Barrhead and Johnstone.

County of *Roxburgh:* the civil parish of Castleton, the municipal Burgh of Hawick, and the police Burgh of Melrose.

County of *Selkirk:* the municipal Burgh of Galashiels.

County of *Stirling:* the civil parishes of Airth, Baldernock, Campsie, Denny, Dunipace, Falkirk, Grangemouth, Kilsyth, Larbert, Logie, Muiravonside, St. Ninians, Stirling and Strathblane, the municipal Burghs of Falkirk and Stirling, and the police Burgh of Kilsyth.

Scottish Plant Registration Station.

A formal Constitution and Code of Rules have been recently adopted for the Standing Committee that assists the Board of Agriculture for Scotland in the management of this station which is situated at East Craigs, Corstorphine. With regard to the membership of the Committee opportunity has also been taken of defining the number of official members to be appointed by the Board, and of providing for the co-option by the Committee of four members in addition to the representatives of societies and institutions who properly form a majority of the Committee. The list of members and the constitution are quoted below:—

I.—LIST OF MEMBERS OF THE STANDING COMMITTEE OF MANAGEMENT.

Representative Members.—David Bell, Esq., 52 Coburg Street, Leith (Scottish Seed and Nursery Trade Association); William Cuthbertson, Esq., J.P., of Messrs Dobbie & Co., Ltd., 52 Moira Terrace, Edinburgh (Scottish Seed and Nursery Trade Association); J. W. Drummond, Esq., of Messrs W. Drummond & Sons, Stirling (Scottish Seed and Nursery Trade Association); John Cairns, Esq., of Messrs Austin & M'Aslan, 89 Mitchell Street, Glasgow (Scottish Seed and Nursery Trade Association); Charles M. Douglas, Esq., C.B., D.Sc., of Auchlochan, Lesmahagow, Lanarkshire (Highland and Agricultural Society); Sir David Wilson, Bart., D.Sc., of Carbeth, Killearn, Stirlingshire (Highland and Agricultural Society); James Elder, Esq., Athelstaneford Mains, Drem, East Lothian (Highland and Agricultural Society); James Gardner, Esq., South Hillington, Cardonald, Glasgow (National Farmers' Union of Scotland); Phipps O. Turnbull, Esq., Smeaton, Dalkeith (National Farmers' Union of Scotland); Dr R. Shirra Gibb, Lauder, Berwickshire (Scottish Chamber of Agriculture); James Rodger, Esq., Rockdale Lodge, Bridge of Allan (Scottish Chamber of Agriculture); C. Buchanan, Esq., Estate Office, Penicuik (Edinburgh and East of Scotland College of Agriculture); Sir James Campbell, LL.D., 14 Douglas Crescent, Edinburgh (North of Scotland College of Agriculture); Principal Paterson, B.Sc., 6 Blythswood Square, Glasgow (West of Scotland Agricultural College); Philip Wilson, Esq., Duns (National Association of Corn and Agricultural Merchants).

Members appointed by the Board of Agriculture for Scotland.—Sir Robert Greig, M.C., LL.D., M.Sc.; James Wood, Esq., O.B.E., M.A., B.Sc. (Agr.); J. M. Caie, Esq., M.A., B.L., B.Sc. (Agr.); A. Main, Esq., M.A., B.Sc. (Agr.); T. Anderson, Esq., M.A., B.Sc. (Agr.).

Members Co-opted by the Committee.—David C. Cuthbertson, Esq., of Messrs Dobbie & Co., 52 Moira Terrace, Edinburgh; Montagu Drummond, Esq., B.A., F.L.S., of the Scottish Society for Research in Plant Breeding, Craigs House, Corstorphine; James H. Elder, Esq., B.Sc., of Messrs William Dods & Son, Haddington; A. W. M'Alister, Esq., Seed Potato Grower and Merchant, Dumfries.

II.—CONSTITUTION AND RULES OF THE STANDING COMMITTEE OF MANAGEMENT OF THE SCOTTISH PLANT REGISTRATION STATION.

1. Whereas the Board of Agriculture for Scotland have established the Scottish Plant Registration Station, the objects of which are to:—

(1) Classify existing varieties of the agricultural plants which are of importance to Scottish agriculture, and to register varieties which are authenticated as new and/or improvements of existing varieties, and so to assist in reducing the number of commercial names descriptive of supposed strains of standard varieties;

(2) Publish accurate information regarding the type, cropping capacity, immunity from disease, relative merits, etc., of varieties as ascertained by testing;

(3) Carry out comparative tests of special strains of these varieties, and so enable the highest standard of production of established varieties to be maintained;

(4) Afford the general agricultural community facilities for the settlement of any disputes regarding the authenticity of stocks, and to assist the Board of Agriculture for Scotland in the administration of the Seeds Act, 1920,

and whereas it is necessary and desirable that in the administration and management of the affairs of the Station the Board shall be supported by the co-operation and advice of the principal associations and institutions concerned in the agricultural industry of Scotland, the Board have set up for this purpose the Standing Committee of Management of the Scottish Plant Registration Station, hereinafter called "The Standing Committee," which shall be constituted as hereinafter provided.

The Standing Committee may appoint from time to time as required a member of the staff of the Board to act as its Secretary. The address of the Standing Committee and of its Secretary shall be the Offices of the Board of Agriculture for Scotland in Edinburgh.

2. The Standing Committee shall be composed of twenty-four members, of whom fifteen shall be representative members, five shall be appointed by the Board of Agriculture for Scotland, and four shall be co-opted by the Committee at its first meeting.

3. The representative members shall be appointed as follows:—

Three by the Highland and Agricultural Society.
Two by the Scottish Chamber of Agriculture.
Two by the National Farmers' Union of Scotland.
Four by the Scottish Seed Trade Association.
One by the National Association of Corn and Agricultural Merchants.
One by the Edinburgh and East of Scotland College of Agriculture.
One by the West of Scotland Agricultural College.
One by the North of Scotland College of Agriculture.

The appointment of the representative members shall be made for a term of five years by a meeting convened and held according to the ordinary practice of the Appointing Body, and the Appointing Body shall forthwith intimate the name of each person appointed to the Secretary of the Standing Committee, provided that the representatives appointed by the several Appointing Bodies in 1918 shall hold office for five years from 1st January 1921.

4. Members co-opted by the Committee shall hold office contemporaneously with the representative members.

5. No person shall be entitled to act as a member of the Standing Committee whether on a first or in any subsequent entry into office until after intimating to the Secretary of the Standing Committee a declaration of acceptance and of willingness to act.

6. Any representative or co-opted member of the Standing Committee who is absent from all meetings of the Committee during a period of two years or who is incapacitated from acting as a member or who communicates in writing to the Standing Committee his wish to resign shall thereupon cease to be a member.

7. Upon the occurrence of a vacancy for a representative member the Standing Committee shall thereupon intimate the vacancy to the Appointing Body by whom the late representative member was appointed, and shall request that Body to appoint a new representative member, who will hold office for the unexpired portion of the period of office of the member who caused the vacancy. Any competent member may be re-elected.

8. Upon the occurrence of a vacancy for a co-opted member the Committee shall thereupon appoint a successor, who shall hold office for the unexpired portion of the period of office of the member who caused the vacancy.

9. The Standing Committee shall hold at least two ordinary meetings in each year, one in Spring and one in Autumn.

10. The Standing Committee shall, at their first ordinary meeting in each year, elect one of their members to be Chairman of their meetings for the year. The Chairman shall always be eligible for re-election.

11. A special meeting may at any time be summoned by the Chairman or any six members of the Committee upon ten days' notice being given through the secretary to all the other members of the matters to be discussed.

12. At any meeting of the Standing Committee there shall be a quorum when as many as five representative and co-opted members, together with one or more members appointed by the Board are present.

13. Every matter shall be determined by a majority of the votes of the members present voting on the question. In case of an equality of votes the chairman shall have a casting vote whether he has or not previously voted on the same question.

14. The Standing Committee may from time to time appoint any Committee or Sub-Committee for superintending or transacting any business with or without power to act in certain circumstances without reference to the Standing Committee. All acts and proceedings of a Committee or Sub-Committee shall be reported to the Standing Committee.

School of Rural Domestic Economy.

THE following Provisional Prospectus of the Craibstone School of Rural Domestic Economy has been issued by the Governors of the North of Scotland College of Agriculture:—

The establishment of a School of Rural Domestic Economy for Girls was one of the purposes in contemplation in 1914, when the estate of Craibstone was purchased by the Governors of the North of Scotland College of Agriculture by means of contributions from Local Authorities, with the assistance of grants from the Development Fund and the Education (Scotland) Fund. Owing to the outbreak of war, the scheme was necessarily postponed. The Governors have now, however, been able to complete arrangements for the establishment of the School, and the necessary alterations on buildings, etc., are being carried out, and suitable equipment provided, at an expenditure of about £5000.

The object for which the School is being established is to provide, for girls who have already received a satisfactory general education, special training in household management, and in the various duties undertaken by women in country districts, and generally to qualify them to carry out efficiently the work of rural life. It is also intended that the course of instruction to be provided should be suited for adoption by Education Authorities as part of the non-secondary courses they will be required to provide under the Education (Scotland) Act, 1918, and referred to in the Scottish Education Department's Circular, No. 44.

The School will be a residential one, and is primarily intended for girls of from fifteen years of age upwards, residing within the College Area, embracing the Counties of Kincardine, Aberdeen, Banff, Elgin, Nairn, Inverness, Ross and Cromarty, Caithness, Sutherland, Orkney and Shetland, and the Western Islands. Students from other districts may, however, be received as school vacancies occur. Provision is being meantime made for about thirty students.

The course of instruction will be very largely of a practical kind, and training will extend over a period of six months. The School will be opened for the First Session on 2nd July, 1923.

The subjects of study and instruction will be:—

(1) Dairy Farming.—Including the feeding and management of cows and calves, buttermaking, cheesemaking, etc.
(2) Poultry-keeping.—Including breeding, hatching, feeding, and housing, preservation of eggs, poultry diseases, and marketing of produce.
(3) Management of Pigs.—Including breeding, feeding, and housing.
(4) Household Work and Management.—Including cookery, needlework, and laundrywork.
(5) Gardening.—Including formation of gardens, cultivation of flowers, vegetables and fruit, preservation and storing of vegetables and fruit, manuring, insect pests, and plant diseases.
(6) Bee-keeping.—Including management, handling and feeding of bees, use of appliances, honey production, and bee diseases.

There are excellent facilities at Craibstone for the carrying on of the School, and for providing instruction in these subjects. The estate, which is conveniently situated about five miles from Aberdeen, on the main road leading to Inverurie and the north, and a little over a mile distant from Bankhead Suburban Railway Station and tramway terminus, has a large and comparatively modern mansion house well adapted for a residental school, and containing handsome reception rooms suitable for use as dining, recreation, and lecture rooms, with a large kitchen, etc., available for instruction in cookery, and all other usual accommodation suitable for a large establishment. There is an ample supply of water of excellent quality. Improvements in the domestic hot water supply are being introduced, and additions made to the lavatory accommodation. A new central heating system is in course of installation. The house is lighted by electricity, generated at a power station on the estate, and a supply of town's gas is installed for cooking purposes.

The kitchen is being remodelled, and a large central range provided, suitable for instructional purposes. Gas cookers are available for domestic cookery, and an ordinary open farm kitchen fire is also provided for instruction. The house is being meantime equipped for thirty resident students, and the necessary resident staff; but accommodation can readily be provided for a large increase in the numbers of students at comparatively small cost. The extensive and well-wooded policies, affording ample scope for outdoor amusements, and the general situation of the mansion house, combine to form a healthful and desirable place of residence.

The home farm of Craibstone, which is in the hands of the

Governors, affords necessary facilities for instruction in the feeding and management of live stock. A small herd of dairy cows will be kept for dairy purposes, and a considerable number of pigs for instruction in breeding and feeding. It is proposed later to give instruction in the preparation and curing of bacon.

To provide a working dairy and a working laundry on a scale suited to the needs of the school, alterations are in course of being carried out on the large building at the home farm formerly used as the Research Institute in Animal Nutrition. The building is well adapted, and, when the alterations have been completed, will provide excellent accommodation for these purposes. In the fitting up of both dairy and laundry no elaborate machinery or apparatus is being introduced, as it is considered that training of much more practical benefit will be given by the use only of appliances which may be found at the students' own homes. The arrangement and fitting up of the building is, however, being carried out so as to ensure the best possible working conditions as regards comfort and sanitation. A lecture room is being provided in this building, while accommodation will also be available for such purposes as milk testing, recording, etc.

The poultry accommodation at Craibstone is being extended by the erection of additional poultry runs and houses, and a large store is being erected for the storage and preparation of food, which will also give facilities for practical training in the construction of poultry houses, trap nests, and other appliances.

For instruction in horticulture there are available a large and well-stocked garden near the mansion house, and large flower and fruit borders in the experimental area, in the Woodlands Field. Suitable plots are also being provided for the students.

The existing apiary at Craibstone is of ample size for the purpose of instruction in bee-keeping. It is situated on a southern slope between the mansion house and the home farm, and contains about fifty stocks of bees, and a honey house fitted with all necessary tools and with appliances for the extraction of honey. A further development of the apiary is in contemplation, to demonstrate the commercial possibilities of honey production in the north.

The resident staff of the School will consist of a matron who will teach housewifery and needlework, a female teacher of laundry work and cookery, and a female teacher of dairying and poultry-keeping. Other members of the college staff will be available for instruction in farm work and management of animals, gardening, and bee-keeping. The whole of the staff will possess qualifications recognised by the Scottish Education Department.

Arrangements will be made for occasional lectures by members of the staff of the Rowett Research Institute in Animal Nutrition, and opportunity will be afforded to the students to visit the Institute and see the experiments in animal feeding in progress.

The fee payable by students attending the School is £35 for the whole course of six months' training. This fee is inclusive of

tuition, residence, board and laundry during that period. The fee will be payable in advance.

Further particulars may be had on application to the Secretary of the North of Scotland College of Agriculture, 41½ Union Street, Aberdeen.

Genetics and Stock-Breeding.

THE following notes on the application of the science of genetics to practical stock-breeding have been supplied by Mr F. A. E. Crew, M.D., D.Sc., Director of the Animal Breeding Research Department, University of Edinburgh.

Genetics is the science which seeks to account for the similarities and dissimilarities in characterisation exhibited by individuals related by a common ancestry, and to define the exact relation between successive generations. It deals with the physiology of heredity—the mechanism by which resemblance between parent and offspring is conserved and transmitted, and with the origin and significance of variation—the mechanism by which such resemblance is modified or transformed.

The central problems of this systematic study of the principles and causes which underlie the origin of the individual are: (1) To define the manner in which the hereditary characters of the individual are represented in the fertilised egg in which he has his beginning; and (2) To demonstrate the way in which these characters become expressed as the development of the individual proceeds.

Genetics as a recognised science has but recently come of age, yet already a very great deal is known of the principles of heredity and variation. Naturally enough, those characters have so far been studied most fully, the hereditary transmission of which has proved comparatively straightforward, and the material used for genetical study have been, among animals, the inexpensive quickly-maturing highly fecund fruit fly (*Drosophila melanogaster*), moths, the mouse, rat, guinea-pig and rabbit.

But out of this work interpretations and theories have arisen which can account for the phenomena of hereditary transmission met with in the course of practical stock-breeding. The theories derived from the experimental breeding work with laboratory animals have indeed been applied to the known facts of heredity and variation in the sheep, pig, dog, horse and cattle, and in all cases the same general principles have been shown to hold true. The fundamental conception of genetics postulates that the hereditary constitution of the individual, established at the time of the union of the ovum and the sperm, decides in great part the future characterisation of the individual—that those qualities alone are inherited which are innate in the germ-cells; this theory is being more and more confirmed as the results of experimental breeding work, of experimental morphology, and of cytology accumulate. The geneticist is justified in his conviction that the phenomena of heredity have a definite knowable basis: that indeed in this matter there are no real mysteries but only lack of knowledge.

The science of genetics has made great strides during the last twenty years, and it has been assumed at times that coincident with this advance in our knowledge of the fundamental laws of heredity there has been an equal and parallel advance in the practical art of breeding. It is, indeed, commonly accepted that any advance in a pure science necessarily involves a corresponding advance in the practice of an associated art or craft. This may be true in the case of the industrial crafts, but it certainly is not so in the case of the relation of genetics and stock-breeding. The art of animal breeding is far in advance of the applied science; a geneticist, for all his knowledge, cannot produce, or tell anybody else how to produce, finer specimens of farm-stock than those now to be seen. In fact, a century before the science of genetics was born there existed animals which were intrinsically as fine and as productive as any existing to-day, if it is taken into account that standards change and husbandry has improved. From time to time new breeds were deliberately fashioned, and it is of importance to note that the methods used by the geneticist in the investigation of his peculiar problems to-day were those employed with such phenomenal success a century ago by the great "improvers." Bakewell, the Collings, Booth, Bates, Francis Quartly, Coke of Holkham, Amos Cruickshank, Hugh Watson of Keillor were applied-biologists and, whether they knew it or not, heredity and variation lay at the basis of all their work. Their methods were empirical, and it can be affirmed confidently that their success was due to the fact that their practices were in exact conformity with the underlying biological principles concerned. In the case of the breeder, experience has resulted in the elimination of those methods which were not attended by success, that is, such as were not in accord with basic biological principles. The geneticist claims no monopoly: the principles of heredity were in operation long before Mendel discovered them, and there can be no doubt that the success of the breeders must have been achieved by practices not violently in discord with these principles. The discovery of these principles therefore could not result in any profound change in the *practice* of stock-breeding.

The breeder has employed the methods of hybridisation and inbreeding associated with selection in the creation of the modern breeds; to-day he practises inbreeding and selection in order to maintain the desired characters of his stock — most of them hereditary characters—and to improve upon them generation by generation, or he seeks hybrid vigour in outcrossing.

These are the very methods by which the scientist has explored the genetical constitution of his material, the very tools with which he has carved out of his experiences the modern theory of heredity. By the use of these methods the geneticist has analysed his animals into their independently heritable characters, and now his experience gained whilst working with the more simply organised sorts of living things has equipped him to engage in the character-analysis of such complex and highly organised creatures as those with which the stock-breeder deals. The present-day knowledge of heredity and variation could never have

been derived from the study of hereditary transmission in the domesticated stock. Mendel found the key to this knowledge because he chanced to choose the culinary pea for his experimental material; and if the younger generation of geneticists feel that they are prepared to approach the problems of the stock-breeder it is because there exists for guidance the work of Mendel, Correns, de Vries, Tschermak, Bateson, Morgan, Johanssen, Punnett, Pearl, Goldschmidt, and of a host of others.

The American Breeders' Association was formed for the purpose of securing the co-operation of those who are interested in the problems of the improvement of the domesticated animals and plants—the geneticist, interested in the study of the problems of heredity, and the breeder interested in practical breeding—so that the art of breeding might be reinforced by the science. There is scarcely a University Department or School of Agriculture in America which has not a Chair of Genetics associated with it. In Great Britain, as far as I am aware, only at Edinburgh is there given a special course of instruction in genetics in its relation to animal breeding. At least it can be said that in the considered opinion of the authorities here the science of genetics has something to contribute to the education of those who in their professional careers will be dealing with the problems of stock-breeding.

To-day the great service to the breeder that the science of genetics offers is that it provides an interpretation of his methods and of his results, so that he is enabled to discard all unessential steps in his practice and proceed confidently and more directly to his goal, to plan the steps of a breeding operation with a certainty and precision which otherwise are lacking.

The science of genetics has shown that specific characters or groups of characters are inherited as independent and definite units. It has furnished a critical appreciation of the value of selection, demonstrating that selection is not a germinally creative or additive process as the breeder so often believes, but rather is a process of sorting out from among a mixture of heritable characters already present in the stock. The geneticist has gained a considerable knowledge of the mechanism of sex-determination and has interpreted the phenomena of sex-linked inheritance (to the profit of the poultry breeder, incidentally), hermaphroditism and sex-reversal. He has demonstrated beyond doubt that certain diseases are truly inherited, and has shown the way in which these could be obviated. He has given an exact meaning to the phenomena of inbreeding, outbreeding and prepotency, and has shown that fecundity, fertility, certain forms of sterility and longevity have a definite genetical basis. He has critically examined the traditional beliefs, and is able, when consulted, to give an authoritative opinion as to their validity. He has given to purity in breeding and to hybridity an exact meaning, and has perfected the methods by which any hereditary character, morphological or physiological, can be subjected to genetical analysis.

It is for the breeder to enlist the co-operation of the scientist.

A man who fiercely disbelieves in the germ-theory of disease will not call in the assistance of a bacteriologist; the breeder who scoffs at the book-learning of the lecture room and laboratory-trained geneticist will not seek his aid in the solution of his many problems. But putting aside all such prejudice it behoves the breeder to examine carefully the results of the work of the geneticist and to consider whether or not the methods of precision employed by the latter, the great body of facts he has ascertained, and the theories he has constructed may not be applied with advantage to the study of those characters which are of importance in the practice of stock-breeding. Let the breeder examine the position and he will surely find that for the solution of his problems the close co-operation of breeder and geneticist is much to be desired.

The circumstances are such that to-day research into the problems of animal breeding is best conducted at an institute. In the first place experimental breeding work with farm animals is too expensive to be undertaken lightly by a private individual. Moreover, it is embarrassed by the well-established pedigree system; it is more profitable to produce specimens of an established breed than to create anything new, for, as definitions go, anything new cannot be pure-bred, and therefore cannot command the market price of an animal in whose family history there is no bar sinister. And since genetical methods involve hybridisation it is not to be expected that the breeders of pedigree stock will practise crossing in the hope that eventually something better may possibly be produced. Animal breeding differs in this respect from plant-breeding: a new variety of wheat, for instance, can claim and is granted its place by virtue of its own inherent qualities, and no one will condemn it because its ancestral history is, to say the least, not distinguished. But for a stock animal it is sometimes better to have had a grandfather than to have a son. This point of view may be forced upon the private breeder, but on the part of the country as a whole such an attitude is undesirable; it might be better to judge an individual upon its own merits and not upon the merits of some ancestor.

To-day there are private experimental breeders, but no private individual has the facilities for pursuing the experiment to that stage when the fundamental biological principles demand elaboration. Experimental breeding work must be conducted in an institute, and until this is possible no considerable application of the science of genetics to the practice of agriculture can be expected. The science has much to offer, and if opportunities are given to the geneticist he will add to that knowledge which may be applied to the practices of the breeder. The extent of the usefulness of genetics to the breeder will be decided by the amount of the support the breeder gives to the institutions which have been organised for his benefit.

The following *resumé* of a paper which appeared in the *Transactions of the French Academy of Agriculture*, also deals

with the application to stock-breeding of the theories of genetics.

The progress of stock-breeding is intimately connected with the possibility of fixing by heredity the variations, or characters, that will improve the quality of animals. Hence the attempt to apply to stock-breeding the knowledge obtained from the researches on heredity that have been carried on for several years in the scientific world.

From among the new facts concerning heredity that are of almost direct application to stock-breeding, the author singles out for special mention those bearing on the dominance of certain characters.

Generally speaking, albinism in all species is recessive. Thus the products of a cross between breeds with pigmented mucous membranes and those with non-pigmented mucous membranes have coloured mucous membranes. Of this there are several instances in cattle.

Southdown rams, when crossed with white ewes, produce lambs with greyish faces and legs.

As dominant characters the author mentions the tuft of the Paduan fowl and the long hair of the guinea-pig. In horses black and bay coats are dominant as regards chestnut, and grey and roan as regards bay.

In cattle, hornlessness is dominant as regards the possession of normal horns. When a polled bull is crossed with a normally horned cow, polled offspring are obtained. This was discovered in England a long time ago by crossing the Angus and Shorthorn breeds. The Sarlabot breed originated from a similar cross between the Normandy and the Angus and Red Polled breeds. This cross was effected in 1852, and the polled character of the progeny was immediately fixed. For the last fifteen years, the author has used the Sarlabot breed in his crossing experiments at Grignon, where its essential character, absence of horns, proved itself to be dominant.

Early maturity, and high milk-yield are some of the dominant physiological characters.

Some colours are sex-linked; thus if a silver Hamburg hen is crossed with a golden Hamburg cock all the hen chicks are golden and all the cockerels silver.

Although the products of the first cross are generally very much alike owing to the presence in the parents of dominant and recessive characters, all homogeneity is lost when the hybrids are mated up together and the recessive characters again make their appearance.

This was discovered some time ago by the Marquis of Béhague in the case of Southdown × Berrichon lambs, and it is therefore not advisable to mate hybrids together, but to obtain them direct by the crossing of pure-bred parents. This is very commonly done amongst sheep-breeders supplying the meat market, and is now gaining ground among cattle-breeders, pig-breeders and even poultry rearers in the case of produce destined for the table. The author maintains that equally good

results could be obtained by extending the same practice to horses.

As soon as experimental research work has been continued sufficiently long for it to be possible to determine the reciprocal relations of the dominance and recessiveness of many characters, the breeder will be able to know beforehand the characters that will reappear in the hybrids and thus be in a position to obtain, at least to some extent, animals suited to satisfy the needs of the moment, or the requirements of any particular market.

For this reason, the author is of opinion that "one of the great objects of the Stock-Breeding Research Laboratories should be the study of new methods of propagation based on scientifically conducted experiments, and applicable to practical stock-raising. These methods could either be applied directly, or after they have proved effective by testing them at special Institutes under the direction of the Agricultural authorities, and at Stock-Breeding centres."

Rat Destruction by Gas.

FOR some time now gassing rats in their burrows has been in progress at the Zoological Park, Edinburgh. Previous to gassing several hundred rats were caught in the numerous "Pied Piper" traps set in different parts of the Zoo.

The gassing has been done by means of a Clayton machine, using sulphur dioxide gas obtained by burning sulphur in the container. This method has proved successful not only in destroying the vermin, but also in deterring rats from re-opening the burrows. A bank which was badly infested was thoroughly gassed and had no holes opened in it ten days later. In the course of operations dead rats were dug out of several burrows, others which had crawled out of unnoticed holes were found dead or dying, and several young rats were found dead in nests. The *modus operandi* was to close up every hole in a burrow with an empty condensed milk tin. Each tin had one end removed and a small hole punched in the other. The tins were well stamped into the holes so that gas could only escape through the small hole in the tin. Gas was pumped into the main entrance of the burrow and continued until it was seen escaping out of several of the tins. The tins nearest the machine were then removed and the entrances examined for dead rats. The tins were replaced, covered with a piece of turf, and the gas applied to one of the holes farther away. After one or two hours' work, which depended on the size of the burrow, all the tins were removed and the holes closed with earth well stamped down.

There is no reason to doubt that, if these operations are carried out as continuously as may be necessary, the rat population of the Zoo Park can be considerably reduced and kept within small limits in the future.

With the permission of Mr T. H. Gillespie, the Director-Secretary, Zoological Park, advantage was taken of these gassing operations to test a new arrangement for using chlorine as the destructive medium. Chlorine is supplied in a liquid state in steel cylinders at the high pressure of 750 lbs. to the square inch. Previous to these experiments the pressure in the cylinder forced the gas through the burrows. This method was found to be uneconomic, as the air in the burrows contained a far higher percentage of chlorine than was necessary to destroy the rats. It was thought that if the gas could be forced through the holes by an air pump, a much smaller expenditure of chlorine with a sufficiently deadly mixture of the gas would be obtained. An ordinary drain-testing machine was purchased and fitted with the necessary connections. This new arrangement proved quite successful; the expenditure of chlorine was reduced to less than half what it was formerly, and the mixture was very deadly. During the two days the experiment lasted, one large and one small rat were dug out of burrows, both dead and both a considerable distance from where the chlorine had been applied. A large rat was found near by in a dying condition; it had evidently crawled out of a hole which had not been stopped. Five large dead rats were taken out of another burrow close to a fowl run. Chlorine was pumped into a burrow close to a dry stone dyke, a most unfavourable place on account of the dispersion of the gas through the dyke; within a minute a large rat appeared and died at the mouth of the hole. A bank was gassed, one hole being left partially open. Later a dead rat was found lying with its head projecting out of this hole. There can be little doubt many other rats were killed throughout the numerous burrows which were gassed, and very few of the holes were re-opened even a fortnight later.

As chlorine, in the small proportion used in gassing a burrow, is an invisible gas, smoke from burning waste and sacking in the drain testing machine was used to make it easily visible; this was found to be an advantage and saved gas.

An expedient which has proved successful at the Zoo has been to fill up the burrows with a mixture of earth and chloride of lime, the whole washed into the holes by a plentiful supply of water. A large filler, mounted on wheels and fitted with a flexible rubber hose of large bore, has rendered easy the application of this method of harassing the rat population.

A comparison of the method of gassing with sulphur dioxide and chlorine under similar conditions shows that the use of sulphur dioxide is cheaper, more convenient and safer than the use of chlorine, but the latter is more effective, and the results are obtained in a much shorter time than with sulphur. The apparatus required is equally portable for both gases. Chlorine has the disadvantage of having to be conveyed by goods train at a high freight as dangerous goods, and cannot be obtained, so far as we are aware, except at Runcorn in Cheshire.

Colorado Beetle.

DURING the great Colorado Beetle scare of the 'seventies of last century, when the United States of America were over-run from the Rockies to the eastern sea-board, fears were aroused that the importation of the pest to Britain might lead to its establishment and to the wholesale destruction of the potato crop. At that time and later, when the life-history and habits of the beetle had been more closely observed, the weight of scientific opinion was against the likelihood of the establishment of the beetle in Britain. Miss Ormerod went so far as to say, in 1890: "From what we now know of its life-history (as well as from the fact that, though nearly fourteen years have passed since it was first certainly known to have reached one of our seaports in this country, it has yet made no settlement), we may reasonably believe that we are not likely to suffer from its ravages."

But new evidence of the adaptability of the Colorado Beetle has come to hand, and again we are faced with the possibility of its establishment in this country. Various attempts at settlement on a small scale have been made by the beetle in different parts of Europe, but in each case the colonies were destroyed by drastic measures, before they had had time to spread seriously, though a slight outbreak at Tilbury in 1901–1902 proved that this pest could survive an English winter. In 1922, however, the most serious outbreak which has yet occurred in Europe was discovered near Bordeaux in France, when about 100 square miles were found to be infested. There is a danger, then, that the beetle may obtain foothold also in Britain, and potato-growers would do well to be on the lookout for the pest—a beetle about half-an-inch long, orange in colour, with ten definite black stripes along the length of the back, or wing-cases. The old Order in Council of 1877 forbade the keeping or distribution of living specimens of the beetle, and made failure to report the presence of the beetle an offence liable to a penalty not exceeding *ten pounds.* A new Colorado Beetle Order of 1922 prohibits the importation to England and Wales of living plants or vegetables from a proscribed area in southern France, including the infested region.

In Scotland no special order seems to be required against the Colorado Beetle, since it is already included in the Second Schedule to the Destructive Insects and Pests (Scotland) Order of 1922, which requires that all consignments of plants, etc., landed from abroad must be accompanied by an official certificate of freedom from the diseases and pests specified in the schedule. Although there is practically no traffic in plants and vegetables direct from France to Scottish ports, the possibility of the importation of the Colorado Beetle from France or elsewhere must not be overlooked, and importers and farmers are warned of the harm that might follow from a lack of vigilance in the early stages of an infestation. Judging from the experience of the United States the losses to be looked for from the establishment of the beetle would be the cost of spraying the crop with a suitable poison insecticide twice a year.

But this would come to be a matter of perpetual routine for potato-growers, since such measures are unlikely to exterminate the beetle.

In view of doubt that may arise as to the identity of the Colorado Beetle and of the necessity for prompt measures, we have arranged that the government zoologists in the Royal Scottish Museum shall report on specimens sent for identification. Such specimens, with full particulars of their occurrence, should be forwarded to The Keeper, Natural History Department, Royal Scottish Museum, Edinburgh.

Cod-Liver Oil for Poultry.

THE following report on poultry-feeding experiments at the Scottish Agricultural Colleges and the Rowett Research Institute has been furnished by Dr J. B. Orr of the Rowett Research Institute, Aberdeen:—

Research work during the past few years has led to the development of new ideas on the subject of food values and the food requirements of farm animals. Much of the experimental work, however, on which some of the widely accepted modern ideas depend has been carried out under laboratory conditions. Though the results of such investigations are of great scientific interest, the practical conclusions which are sometimes drawn from them should be received with caution. It frequently happens in research that subsequent work shows the original interpretation of an experimental result to have been inadequate. Judgment on the practical value of research results should be withheld until they have been applied and tested under practical conditions.

To enable such practical tests to be made in connection with poultry investigations, it was arranged in the summer of 1922 to carry out a number of feeding experiments concurrently at the poultry departments of the three Scottish Colleges of Agriculture, and at the Rowett Institute. The nature of the experiments to be conducted was agreed upon at a conference of the Heads of the Poultry Departments. The work was then done independently at each centre. In each experiment, therefore, usually four tests were done simultaneously, and the results noted by four different observers. At the close of each set of experiments another conference was held, when the recorded results were discussed.

The chief subject of investigation during the past year has been the value of cod-liver oil for poultry, under conditions such as are common at a farm, and fed with commonly used feeding-stuffs. Experiments were carried out to determine the influence of the oil on (*a*) growth, (*b*) egg production and (*c*) the hatchability of eggs.

In some of the experiments the fuel value of the cod-liver oil was balanced by adding to the food of the control pen an equal amount of linseed oil. This oil has little or no "vitamin A,"

which is abundantly present in the former oil; and is supposed to give it a special value. In other experiments this adjustment was not made, the ration with cod-liver oil being tested against a ration with no oil.

In the earlier experiments anti-scorbutic vitamin was provided in the ration, but this was omitted later, as work done at the Rowett Institute last year proved conclusively that there is no necessity to make provision for "vitamin C" in the diet of poultry.

A mass of data has been obtained, some of which will be reported in detail in subsequent publications. The present preliminary report is intended to give only a general idea of the nature of the results obtained.

Growth.—At each station the diet usually fed there to chickens was taken as the basal ration. In no case did it contain oil. Cod-liver oil was added to the ration fed to one pen; another pen of closely related chicks, hatched at the same time, received the basal ration only, or the basal ration plus linseed oil.

At the East of Scotland College, two pens, each with ten pullets, eleven weeks old, were given a basal ration of cereal grains, cereal products, fish meal, dried yeast, with grit and oyster shell. The birds had a run on bare earth with no green vegetation. To the food of one pen 1 cc. of cod-liver oil per bird per day was added: to the food of the other an equal amount of linseed oil. The following figures show the respective rates of gain in weight in grams:—

	Average initial weight.	Average gain in weight per bird per day.	
		First 50 days.	230 days.
Cod-liver oil . .	616·4	12·2	5·00
Linseed oil . .	613·8	11·5	5·04

At the station of the West of Scotland Agricultural College an experiment was done with three groups, each of seventy chicks. The basal ration consisted of seeds, cereal grains and cereal products and fish meal. One group received the basal ration only; a second received in addition $\frac{1}{8}$ rising to $\frac{1}{2}$ cc. of cod-liver oil per bird per day. A third group received an equal amount of linseed oil. The oils were added at the beginning of the second week after hatching. The average weights at the end of forty-eight days were:—

Basal ration only	370·5 grams.
„ „ + Cod-liver oil . .	344·9 „
„ „ + Linseed oil . .	367·7 „

In similar experiments at the Rowett Institute no increased gain in weight was obtained with cod-liver oil.

Egg Production.—In these experiments the hens were enclosed in runs which allowed 20 to 30 square yards per bird. In each experiment the housing, extent of run and nature of ground were identical in the different pens. The amount of oil given varied in the different sets from 1 cc. to 5 cc. per bird per day. The results showed no evidence of any beneficial influence that could be ascribed to either cod-liver oil or linseed oil. At the West of Scotland College, where the amount of oil given was 5 cc. per bird per day, the results seemed to indicate that both oils fed over a long period had a depressing effect on egg production. The basal ration consisted of cereal grains, and cereal products plus fish meal, with lime stone and oyster shell grit. The figures for pens of twelve hens each over a period of eight months were:—

Basal ration only	1702 eggs.
„ „ + Cod-liver oil . .	1493 „
„ „ + Linseed oil . .	1463 „

Hatchability—Eggs from the hens in the egg production experiment were hatched to determine whether cod-liver oil or linseed oil, fed to the hen, had any influence on the hatchability of the eggs. At the date of writing all the data of the tests are not available, but the results obtained at three of the centres seem to indicate that the percentage hatchability is not definitely raised by feeding cod-liver oil to the hens.

It should be stated that these practical feeding experiments do not prove that fowls do not require "vitamin A." Some other experiments carried out at the Rowett Institute show that for birds kept in strict confinement and fed on certain deficient rations, the addition of cod-liver oil may be followed by beneficial results. The experiments dealt with in this report were of a purely practical nature. They only show that, for fowls fed on a ration well balanced with regard to the known food constituents, and housed under conditions such as occur in practice on a farm, the addition of cod-liver oil to the ration is not followed by any beneficial result. It is interesting to note that somewhat similar results with cod-liver oil have been obtained in recent investigations in pig-feeding. If the ration is properly balanced with regard to mineral matter, the addition of cod-liver oil does not lead to any increase in the rate of growth.[1]

Statistics of Various Systems of Farming in Scotland.

THERE has of late been much discussion of the relative productiveness of various systems of farming, *e.g.*, grain-growing, milk production and stock-feeding. To reach an exact comparison fuller data are required than are given in this article, but the figures that follow will, it is hoped, be of interest, as showing how wide are the variations in the use that is made by Scottish farmers of their land. These figures are based on the returns for the year 1922.

[1] *See* page 279 of this *Journal.*

Four districts have been selected—the western district of East Lothian, the Deer district of Aberdeenshire, the Kelso district of Roxburghshire, and the Kilmarnock district of Ayrshire—as examples of districts producing principally grain, cattle, sheep and milk respectively. They will be here referred to as Haddington, Deer, Kelso and Kilmarnock. The total area of these districts is, in round figures, as follows:—Deer, 165,500 acres (259 square miles), Kilmarnock, 122,500 acres (191 square miles), Kelso, 95,500 acres (149 square miles), and Haddington, 93,500 acres (146 square miles). The method of comparison adopted is to reduce the figures in all cases to a ratio per 1000 acres of crops and grass, and all the figures given are to be regarded as index figures on this basis. The acreage of rough grazings must be treated separately; it would obviously be absurd to combine it with the land in ordinary agricultural use for any purpose of comparison. The index figure of rough grazings is therefore to be regarded as representing an "outrun" attached to the 1000 acres of crops and grass. It is, of course, of importance only in relation to the grazing of sheep. The figure for Scotland as a whole is 2039 acres, but those for all the districts here considered are naturally much lower. Kelso heads the list with 604, Kilmarnock has 342, and Haddington 206, while Deer has only 34.

Taking first the distribution of land in holdings, we find that in Kelso there are 4½ holdings per 1000 acres, in Haddington 5¾, in Kilmarnock 11, and in Deer 18, the Scottish average being 16. Conversely, the average size of the holdings in the various districts is—Kelso 220 acres, Haddington 176, Kilmarnock 93, and Deer 55. Such an average figure is of no great value in itself, but the comparative figures illustrate the wide variations that exist in the distribution of land. From a special tabulation made ten years ago it appears that the percentage of land comprised in holdings of the sizes specified was as follows:—

District.	1-50 acres.	50-150 acres.	Over 150 acres.
	Per cent.	Per cent.	Per cent.
Kelso	2½	5	92½
Haddington	2¾	8¼	89
Kilmarnock	6	52½	41½
Deer	20	44	36

Deer is pre-eminent in the proportion of its agricultural land that is under rotation, permanent grass accounting for only 65 acres per 1000, while Haddington has 183, Kelso 241, and Kilmarnock 554, the Scottish average being 294. Probably no district of comparable size in Great Britain has so high a percentage of arable land as the north-east of Aberdeenshire. On the other hand, Deer has a high proportion of land under rotation grasses and clover, amounting to 444 acres, while Kelso has 320 (which is also the average for Scotland), Kilmarnock 266, and Haddington 242. Grain crops account for 368 acres in Haddington, 349 in Deer, 289 in Kelso, and 144 in Kilmarnock, while green crops cover 198 acres in Haddington, 150 in Kelso,

141 in Deer, and only 33 in Kilmarnock; the Scottish figures are 261 and 122 respectively. The predominant rotations are the four-course in Haddington, the five-course in Kelso, and the six-course in Deer, while Kilmarnock has a custom of its own. The figures for Scotland indicate an approximately equal division between the five-course and the six, but this broad average covers many local variations.

Haddington is the only one of the four districts that grows wheat in any quantity, its produce per 1000 acres being 361 quarters, while Kelso and Kilmarnock produce less than the low Scottish average of 67 quarters. Haddington also leads in barley with 778 quarters, Kelso coming next with 547, and Deer yielding only 64; the Scottish average is 156. As Deer produces practically no grain but oats, it has the high yield of 1520 quarters, Haddington following with 1282, while Kilmarnock has 787 and Kelso 761; the Scottish average is 1018.

Haddington shows the greatest produce of potatoes, 540 tons, which is more than double the Scottish average of 252; Kilmarnock has 136, Deer 112, and Kelso 84. Haddington has also the largest yield of turnips and swedes, 2447 tons, but is closely followed by Kelso with 2240, while Deer has 1370 and Kilmarnock 288; the average for Scotland is 1456. Haddington also produces 71 tons of mangolds and Kilmarnock 16.

The yield of hay from rotation grasses and clover shows less variation than other crops; the Scottish average is 144 tons, while Haddington has 231, Deer 177, Kilmarnock 163, and Kelso 115. Kilmarnock is the only district producing meadow hay in any quantity, viz., 140 tons, mainly from timothy meadows, while Kelso produces 21, Haddington 15, and Deer only 4.

Coming to live stock, we find that in Scotland as a whole there are 45 horses per 1000 acres. Deer has 53, Kilmarnock 37, Haddington 33, and Kelso 26. The position of Deer is no doubt due to the large number of small farms in the district, while in Kilmarnock the comparatively small proportion of land under grain and green crop is set off by the extensive use of horses for the carriage of milk.

Cattle may be divided into two broad classes—dairy and breeding cattle, including cows, heifers and bulls, and other cattle, including feeding cattle and calves. As regards the former class, Kilmarnock is pre-eminent with 243 per 1000 acres; Deer comes a long way after with 76, while Haddington and Kelso have only 25 and 23 respectively. Of other cattle Deer has 205, Kilmarnock 151, Kelso 62, and Haddington 58. Thus of cattle of all kinds Kilmarnock has nearly 400 and Deer about 280, while the other districts are under 100; the Scottish average is 243. The comparison is, however, unfair to Haddington, as its stock of feeding cattle is low in June.

Kelso is a long way the first in sheep with 2277 per 1000 acres, Haddington coming next with 870, while Kilmarnock has 343 and Deer 223. Here allowance must be made for rough grazings, as mentioned above. This allowance is of still greater importance in considering the average figure for Scotland, which is 1414. It

should also be noted that in June the sheep population is at its maximum. A special tabulation has been made of the returns for a group of large farms in the Kelso district that have no rough grazings. In this group there are 120 acres of permanent grass per 1000, and as the arable land is worked on the seven-course rotation, the whole area of grass is about 625 acres. These farms carry fully 2000 sheep per 1000 acres, at the same time producing 250 quarters of barley and 1000 quarters of oats.

Scotland is notoriously deficient in pigs, the average number per 1000 acres at 3rd June 1922 being only 32. Of the selected districts Kilmarnock comes first with 53, indicating the association of pig-feeding with dairy farming, while Haddington has 33, Deer 26, and Kelso 20.

Kilmarnock also leads in poultry with 1590 head of all kinds per 1000 acres, closely followed by Deer with 1560; Kelso has only 485 and Haddington 460, while the Scottish average is 970. These figures show that the density of the poultry population is in inverse ratio to the size of holdings. The group of large farms mentioned above has only 130.

Particulars have been obtained in the last two years of the number of workers employed on each holding, excluding the occupier, his wife and domestic servants, but including members of the occupier's family other than his wife. In Scotland as a whole the number of regular male workers per 1000 acres, as returned on 3rd June 1922, is 17·3. Haddington shows the highest figure, 22·7, and Deer is also above the average with 19·2, while Kelso has 16·6 and Kilmarnock 13·0. Female workers are also most numerous in Haddington with nearly 10; Kilmarnock follows with 7·4, Kelso with 5·9, and Deer with 3·8, the Scottish average being 4·4. Taking all regular workers, Haddington has 32·6, Deer 23·0, Kelso 22·5, and Kilmarnock 20·4. The Scottish average is 21·7, and the selected districts are as a whole above it, as would be expected from the fact that they have been chosen to illustrate high production along certain lines. Casual workers on the other hand were, at the date of the returns, less numerous proportionately in these districts. The Scottish average is 4·7, and the district figures are as follows:—Haddington 5·5, Kilmarnock 4·1, Deer 2·3, and Kelso 1·9.

Agricultural Conditions.

THE weather during March was fairly favourable for outdoor work; considerable arrears were overtaken, and good progress was made with the sowing of cereals and the planting of potatoes. The month of April was cold for the most part throughout the whole of Scotland, east winds were prevalent, and in most districts night frosts were frequent. Fair progress was made during the month with the normal operations of the season, but growth was slow, and in many districts young crops were checked. The weather during May was unusually cold, and some snow fell in several districts. In the northern and north-eastern counties and in the western islands the month was exceptionally wet; outdoor work was

practically impossible in these districts, and cultivation fell more or less into arrear. Speaking generally, the month was very unfavourable for agriculture, and, as a result of the inclement conditions, grain crops made little progress, and the growth of grass was checked. Turnip sowing was delayed in several districts owing to the difficulty in securing a good seed-bed.

Wheat was checked owing to the cold weather in April and May; the plant, however, is generally healthy, and with warmer conditions the prospects would be fairly satisfactory. From East Perth and North-East Fife it is reported that some damage has been caused to the young braird by wireworm, while in Berwick the plant has lost colour owing to frost. Estimates of the acreage sown have been furnished by the Board's Crop Reporters, and from these it would appear that the area under wheat is somewhat smaller than last year. The greatest decreases are indicated in Berwick and North Ayr, where the area is estimated to be less than last year by 10 per cent., while in the Lothians, Kincardine and Dumfries the estimated decrease is 5 per cent.

Barley was generally reported at the end of May to be backward in growth owing to the continued cold weather; in several districts the plant is thin on the ground and is lacking in vigour. Wireworm and grub are prevalent in Roxburgh and to a less extent in East Perth and North-East Fife. Estimates of the acreage sown indicate decreases of 10 per cent. in South-West Perth, and of 5 per cent. in Central Perth, Sutherland, North Ayr, Dumfries and in some districts of Aberdeen. An increase of 10 per cent., as compared with last year, is reported from North-East Fife and one of 5 per cent. from Uist. Elsewhere the area under crop is estimated to be practically the same as in 1922.

The reports on the oat crop are far from satisfactory, and the present prospects give cause for some anxiety. The braird was unusually slow in appearing, and while the plant is generally healthy on good land, in many parts it is thin on the ground, weak and discoloured. Grub is in evidence almost everywhere, and in Kintyre, Bute, North-West Lanark and South Ayr the crop is so badly affected that second sowings have been necessary. In Stirling, many fields have been resown with barley. The area sown is estimated to be somewhat less than that of last year in Central Perth, the Lothians, Peebles, North Ayr and North-West Lanark. On the other hand, an increase of about 8 per cent. is estimated in Central Aberdeen, while in Kincardine and Berwick the area is reported to be greater by about 5 per cent. Taking the country as a whole the acreage under the crop will probably show a slight diminution as compared with the previous year.

Beans are generally reported to be looking well, but on late sown fields growth has been slow. Rye-grass and clover seeds made little or no progress during May, and almost everywhere growth is unusually backward for this period of the year. In many districts it is anticipated that the yield of hay this season will be lighter than usual.

Potato-planting was completed during May, except in a few of the north-eastern and eastern districts; in Caithness a considerable area remained to be planted at the end of the month. In Aberdeen the seed-bed was unsatisfactory owing to the sodden condition of the soil, but elsewhere planting appears to have been carried out under fairly favourable conditions. Except in a few districts the braird was not showing at the end of May. In South Ayr early varieties suffered severely owing to the cold winds prevailing during the month, while in Wigtown some damage was caused by frost and hail. The area sown is estimated to be less by 25 per cent. in South-West Perth, by 20 per cent. in Renfrew and Kirkcudbright, by 15 per cent. in North-East Aberdeen and by 10 per cent. in Kincardine, North-East Fife, Dumfries and Wigtown, while from several other districts decreases up to 5 per cent. are reported. From these preliminary estimates it would thus appear that there will be a substantial diminution in the area under the crop as compared with last year. The sowing of turnips and swedes has been later than usual this year. Swedes were mostly sown by the end of May, but in many districts a considerable acreage of yellows and whites had yet to be sown at that date. The sowing of mangolds was completed before the end of May in Berwick and the south-western counties.

The reports on the fruit crop are rather disappointing. In South-East Perth the blossom on plum trees was seriously damaged during May by cold winds, but orchard apples and pears promise well. In North-East Forfar the prospects for fruit are stated to be good. Elsewhere, however, fruit trees and bushes have suffered from frost and cold winds, and the present prospects are rather doubtful.

Pastures are unusually backward everywhere, and in some districts grass was not so plentiful at the beginning of June as it was at the end of April. Live stock made little progress during May, and in some cases cattle had to be re-housed so as to prevent them losing condition. The supply of purchased feeding stuffs has been necessary for dairy cattle in order to maintain the yield of milk. The fall of lambs has been a good average, both on arable and hill farms, the only unfavourable reports, so far as numbers are concerned, being from North-East Aberdeen, Dumbarton and Stirling, while in Caithness twins were fewer than usual. On upland farms the progress of the lambs has been much retarded owing to the severe weather during May, and to the fact that the ewes are not milking as well as usual. In Wigtown a high death-rate is recorded from scour; in Central Perth considerable losses have occurred owing to wool-ball, and several deaths are reported from Shetland owing to the same cause. It is reported from Stirling and Berwick that the death-rate generally has been considerably above the normal.

The supply of regular workers is generally plentiful, but men and women milkers are scarce in Ayr, while in Renfrew women dairy workers are barely sufficient for requirements. Specially

full reports on labour were obtained at the end of May, in view of the hiring fairs that were held in many districts during that month. The wages being paid are detailed in the Monthly Agricultural Report for 1st June.

RECENT PERIODICAL LITERATURE.

A number of the following extracts and summaries are taken from recent bulletins of the International Institute of Agriculture. Full references to the bulletins, and to the original publications quoted therein, may be obtained on application to the Secretary, Board of Agriculture for Scotland, York Buildings, Edinburgh.

The So-called Sheep-tracks on Grassy Banks. *H. Ødum, Danmarks Geolog. Undersøg., 1922.*—On steep grassy slopes in all parts of Britain there occur close ridges which run along the face of the slope. These ridges are generally known as "sheep-tracks" or "sheep-roads," and it has been taken for granted, without much enquiry, that they were due to the presence and traffic of sheep or goats. Observers in this and other countries, however, have long doubted the validity of this explanation, and now that a Danish geologist has made a detailed study of the phenomenon, these doubts have proved to be well founded. The "sheep-tracks" or terracettes, as the author calls them, are very widely spread, for they are known in Denmark, Scandinavia, Germany, the Faröes and Iceland, as well as in Britain, and everywhere the people have attributed their presence to sheep. The phenomenon, however, is a purely geological one, and is likely to take place wherever the dip of the bank is sufficient, loose earth is present, and the surface bears a coat of vegetation. On such a slope, owing to tension on the surface, numbers of small parallel cracks eventually open, running along the slope. The small mass of turf between two cracks settles down in a position of greater equilibrium, which is attained as the surface of the mass rotates, so that the inclination of its surface is less steep than that of the bank as a whole. Once this process has begun, there is an inevitable tendency for the ridging to increase and become more definite, for the soil washed down by rain is caught in the grass fringing each ridge and settling there ultimately builds up a horizontal surface on the ridge. The familiar terracettes of grassy banks have, then, nothing to do with the presence of domestic animals, but represent a kind of settling into stable condition of an unstable surface.

Investigations on the Assimilability of Phosphoric Acid in Basic Slag and certain other Phosphates. *I. J. G. Maschaupt, Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations.*—The author has made a special study of the question of solubility of phosphates in the soil before assimilation by roots of plants, in order to resolve the problem from the practical standpoint.

The results are summarised as follows: The nutritive value of a phosphate is determined in the first place by the solubility of the phosphoric acid. Plants no doubt have therefore certain requirements as regards the concentration of phosphoric acid in soil water.

Determinations of solubility such as are in general use in agricultural chemistry are therefore justified in principle as they are made to ascertain the practical value of the phosphates.

As regards the methods by which to determine solubility, the Wagner 2 per cent. citric acid method demonstrates the lower value of basic slag in this respect when compared with some other phosphates. This method is, however, insufficient when applied to other phosphates, as too great a value is attributed to tricalcic phosphate and bone meal.

In classifying the phosphates according to the yields obtained thereby, the following list is given in order of value:

Basic slag, pure tricalcic phosphate, bone meal, Florida phosphate, Algerian phosphate.

Classified according to solubility in water containing carbolic acid, the same order of sequence is given, with the exception of Florida phosphate, which is inferior to Algerian phosphate.

Classified according to percentage of phosphoric acid, contained in the phosphates and absorbed by the plants, the same order still holds good.

The author draws attention to the fact that the figures recorded in these trials to determine the value of phosphatic manures refer only to *oats*, and subject to the special conditions maintained during the experiment. The alkaline reaction on the culture solution due to the presence of nitrate of soda should, for example, have a marked effect.

It would be interesting to repeat the tests with the same phosphates but with other plants, and with the addition of other nitrogenous salts, *e.g.*, ammonium nitrate, sulphate of ammonia, calcium nitrate, etc.

The Effects of Acid and of Alkaline Fertilisers, Spitsbergen, Netherlands. *J. Hudig and C. Meyer, Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations.*—Manurial experiments have been made by the authors for six years at the experimental station at Groningen (Netherlands) with the special object of studying the effect of acid and of alkaline fertilisers.

The substances applied were: superphosphate and ammonium sulphate, basic slag, Chile nitrate and carbonate of lime. The plants used included barley, oats, potatoes and peas, as well as barley with clover and serradella (*Ornithopus sativus*). The authors learned from experience that an acid fertiliser should never be used for a soil that is already acid; in such a case, ammonium sulphate must never be applied. Chile nitrate may give good results, provided the soil is not too acid.

By adding a sufficient amount of carbonate of lime, the fertility of an acid soil can be improved, but the good effect will be neutralised if the use of an acid fertiliser is continued, because such a fertiliser not only acts upon the plants for which it was intended, but also on the subsequent crop. An acid soil, in which the authors had planted potatoes, produced a small crop of poor quality owing to its need of lime, even after a dressing with Chile nitrate. Acid soils must be neutralised with carbonate of lime before potatoes can be grown.

A problem presenting a good deal of difficulty is to determine practically the *amount* of lime to be added to neutralise soil. The authors are of opinion that it is necessary to estimate the acidity of the soil in the laboratory, and for this purpose they devised a "conventional" method, because soil acidity, which generally depends upon the humic substances present, is subject to considerable variation in the course of the year, and is a very indefinite property. The best indicator for this reaction is the plant itself. The authors made a series of experiments with given mixtures of soil and calcium carbonate. The results obtained agree very well with those given by titration in the laboratory.

The authors are convinced that the acid, or alkaline reaction of soil, would not in itself be sufficient to cause disease in cereals. The alkaline reaction appears to be connected with the influence of bacteria. The fact that leguminosae grow badly on acid soil and better on alkaline soil, is probably to be attributed to the life conditions of the root bacteria.

The optimum is evidently not the same for all plants, and must be ascertained for each given species.

It is not known why an acid fertiliser is so injurious when applied to an acid soil, especially as the experiments made show the acid reaction not to be the cause of disease. In practice, however, this phenomenon must be taken into account.

The following are the final conclusions reached by the authors after their six years' work :—

1. Except in rare cases, acid fertilisers should never be used for acid soils.
2. Leguminosae require a neutral or slightly alkaline soil, and grow badly on acid soils.
3. Potatoes need a slightly acid soil.
4. It is possible to determine in the laboratory whether a soil needs lime, and the amount necessary to neutralise it.

Composition of Stassfürt and Alsace Potash Salts. *A. Vürtheim, Verslagen van landbouwkundige onderzoekingen der Rijkslandbouwproefstations.*—The author has made thorough analyses of a series of samples of potash salts of French and German origin. He states that the German salts generally consist of a mixture of natural and artificial salts, and a certain percentage of sulphates and chlorides of calcium and magnesium of the "hartsalz" and "carnallite" type. The kainits contain as much as 12·4 per cent. potash. Other salts contain 20 per cent. and 40 per cent. potash. The potash content of the latter has been raised by the addition of artificial potassium chloride or has been purified by crystallisation.

The 20 per cent. Alsatian salts never contain magnesium sulphate; the composition is much less varied than in the case of German salts. The chief constituent is fairly pure sylvinite, combined with a small quantity of anhydrite and argillaceous material.

From the point of view of fertilising value these salts are equivalent to the 20 per cent. German salts.

Food Value of Coconut Cakes, Coconut Meal and Ground Linseed for Dairying. *N. Hansson, Kungl. Landtbruks-Akademiens, Handlingar och Tidskrift.*—During the winter months of 1921-1922 the Department for Feeding Research of the Swedish Agricultural Experiment Station has carried out feeding experiments in order to ascertain the food value of coconut cakes, coconut meal (extracted) and ground linseed for dairy cows. The feeding experiments with the coconut foods have been carried out as group trials with forty-two cows at two farms. In these experiments a daily ration per cow of 1·5 kg. of coconut cakes or of 1·5 kg. of coconut meal was replaced by a ration of 1·8 kg. of wheat bran and 0·15 kg. of peanut cakes. With linseed only one trial (carried out as a period trial) has been made. In this experiment a ration of 1 kg. of wheat bran was given. The results obtained in these experiments can be summed up as follows :—

(1) That coconut cakes and coconut meal are excellent foods for dairy cows, with a favourable effect on the milk production and in dietetic respects.

(2) That coconut cakes as well as coconut meal increase the percentage of fat in milk.

(3) That this effect is dependent partly on the percentage of fat in the food mentioned, so that cakes containing 7-8 per cent. of fat, on the whole, increase the percentage of butter-fat in milk more than meal containing only 3-4 per cent. of fat.

(4) That this effect of the coconut foods furthermore is dependent on the amount of the coconut foods given daily, the length of the periods of the trials and the other foods given at the same time.

(5) That the capability of the coconut foods to increase the percentage of butter-fat in the milk is so general that, of thirty cows which have been given this feed in these experiments, twenty-eight have reacted in the same direction, while it was found that one of the two other cows was suffering from an abnormal state of health.

(6) That if consideration is given to the effect of the coconut foods, both as regards the quantity of milk and the production of fat, about 0·85 kg. coconut cakes of the composition proved here ought to be considered equal to one food unit.

(7) That under the same conditions about 0·90 kg. of coconut meal with 3-3·5 per cent. of fat is required to equal one food unit.

(8) That ground linseed given to dairy cows considerably increased both the percentage of fat in the milk and the total butter-fat production.

(9) That 1 kg. of linseed of normal composition seems to have about the same nutritive value as 1 kg. of ground oats plus 1 kg. of wheat bran.

(10) That ground linseed is well liked by the cows, has a good dietetical effect on the animals, as well as a favourable influence on their coat of hair.

The Effect of the Age of the Sire and Dam on the Quality of Offspring in Dairy Cows. *C. L. Allen, Journal of Heredity.*—The statement that an animal is more valuable for breeding purposes when it has reached full growth is based on the following reasoning: either the mature animal because of its physical development must be more able to impress its characters on its progeny, or in the process of maturity the animal must acquire something, due to training or environment, which can be transmitted to its offspring. After a century of study, the important question is far from settled as to the possible effect of environment on the transmission of a tendency to increase or decrease certain quantitative functions.

It would be very advantageous to know definitely whether the young born of immature parents are as valuable for production and for reproducing their kind as those born of more mature parents. It is the aim of this paper to show whether the average age of the parents of a group of high producing or superior cows is greater than the average age of the parents of a group of comparatively low producing or inferior cows. An attempt is also made to show the percentage of distribution of offspring for the various ages of both sire and dam; the age when cows actually make their best records; and whether the offspring of very young or very old animals are inferior.

The data reported in this paper were taken from the Advanced Registry Year Book and the Herd books of the Holstein Friesian Association of America. The superior class of animals chosen had yielded 24 lb. or more of butter-fat in seven days; the comparatively inferior class of cows produced less than 14 lb. of butter-fat in seven days. Three generation pedigrees were compiled, and the following results have been obtained.

There is no significant difference between the age of the superior and the inferior producing cows. An old animal will not necessarily be high producing (averages of 506 progeny): as far as the age of either parent is concerned, the young born at one period in life seem to be just as valuable as young born at any other age. Age evidently has no effect on the quality of the offspring. The sires of the superior class average 46·4 months at the birth of their offspring, and those of the inferior class rather less. The largest number of offspring were born when the sires were from two to three years of age; improvement has been based on selection of young sires rather than older ones.

A bull cannot be called an established sire until the heifers have milked at least one year, and not until he is five years of age. That a tested sire is more valuable is shown by the fact that 21·1 per cent. of the superior cows are daughters of bulls of equal age, compared with only 15·9 per cent. of inferior cows. This may seem to conflict with the opinion that the bull when old is not more valuable, but these data prove that such a bull is not more valuable as a parent.

There is a distinctly larger percentage of superior class producers born of dams of five years old than of low producers. This, perhaps, may be attributed to the fact that the superior class received better care and were bred younger.

The offspring from very young parents or from very old parents are of equal value from the productive standpoint.

On the average, cows make their best records as regards milk and butter-fat production at about six years of age.

Cow-Testing and its Value. *A. H. White, Agricultural Gazette of Canada.*—An excellent example of the good results to be obtained where dairy records are used to guide the operations of breeding, feeding and selection. At

the end of the first year of testing in 1911, the average production of fourteen cows in the herd in question was 5438 lb. milk; in 1921 with fifteen cows the average production was 10,080 lb. milk and 371·3 lb. fat.

The Pasteurisation Process and its Effect on the Vitamine Content of Milk. *A. Bruce Macullum, Agricultural Gazette of Canada.* - The author, after consideration of data collected from various sources, has come to the following conclusions.

Pasteurisation of milk has no effect on vitamine B or on vitamine A. In the case of vitamine A, pasteurisation in a closed container is essential. The loss of vitamine C may be as much as 70 per cent. The loss of antiscorbutic vitamine is less marked after forty-eight hours than immediately subsequent to heating.

Methods of Measuring the Volume of Cream on Milk. *H. A. Harding, F. W. Kelly and E. S. Chrisler, Journal of Dairy Science.*—In the city trade the appearance and volume of the cream on the milk as delivered to the consumer is a matter of considerable commercial importance. This has been recognised by the milk industry and different methods of measuring the cream have been adopted. There is, however, an almost complete lack of literature on this subject. The authors have made a study of the various methods, and finding that they were not satisfactory for the study of the influence of plant operations on the volume of cream, there has been developed a simple and accurate method of measurement which has been found readily applicable under working conditions.

This method consists in filling round-bottomed test tubes 1 inch in diameter, to a depth of 204 mm. with the milk to be tested. The tubes are cooled immediately in ice water and then kept in a temperature of 40° F. for approximately twenty hours. The depth of the cream layer is measured in millimetres and each millimetre of cream represents 0·5 per cent. of cream by volume. The volume of cream as determined in this way, agrees closely with the volume of cream in milk bottles under similar temperature conditions.

This method has been extensively tested in milk plants and its advantage lies in the fact that by its use a large number of samples may be collected during a single day, the samples stored compactly, and measurements of the cream made quickly, accurately and quantitatively.

Effect of Cupric Treatments on the Wheat Yield. *A. Morettini, Le Stazioni sperimentali agrarie italiane.*—In a preceding article (*Stazioni sperimentali agrarie italiane*, 1921), the author has shown the advantage of substituting "polvere Caffaro" (oxychloride of copper), or powdered copper carbonate (1), for the usual treatment with a solution of copper sulphate in the control of smut (*Tilletia Tritici*). Experiments have proved that the dry treatment prevents smut without in any way injuring the germinating capacity of wheat. It has also been shown that germination after immersion in a 0·5 to 1·5 per cent. solution of copper sulphate is not affected. This fact is confirmed by other investigators (Krauss, Wollny, Kidd and West); others consider it has an injurious effect (Darnell-Smith and Ross; Mackie and Briggs); and others again maintain that it is actually beneficial (Harry).

In the present case, the author proposed to investigate the effect of the two methods of treatment (with solution or with powder) upon the productivity of wheat, without any reference to their resistance to disease.

The results of the experiments agree in showing a higher yield for the seed treated with powder as compared with untreated seed, or with water, or with a solution of copper sulphate. Of the fungicides employed, the copper carbonate gave the best results.

By means of germination tests made with seed subjected to different treatments. the author has ascertained that the increased yield following the dry treatments is due to an increase in the germination capacity. The difference between the germination capacity of the control seed and of that of the seed treated by the dry process was, on an average, 2 to 3 per cent. with copper carbonate and 2 per cent. for "polvere Caffaro.'

The increased yield in both cases appears to be due chiefly to the toxic action of the two copper compounds upon the moulds and bacteria that attack the germinating cariopsis and these compounds have no injurious effect on the embryo. This allows the grain to develop a higher germinative capacity; it is possible also that the copper may exercise a stimulative effect upon the growth of the seedling.

In conclusion the author recommends the use of powder fungicides rather than solution.

The More Important Apple Insects. *U.S. Dept. Agr., Farmers' Bulletin, No. 1270.*—Under the above title the U.S. Department of Agriculture has recently issued a pamphlet of ninety-five pages, dealing with insect pests of apple trees. The pamphlet, which deals with over seventy pests, is of much too detailed a character to be summarised in these pages; it is sufficient to say that it discusses the appearance, life-history, and damage done by each specific insect pest, and in each case recommends the remedies which experience has proved to be most successful in destroying or controlling the pest. The work, although it applies more particularly to conditions in the United States, ought to be in the hands of every apple-grower.

Weevils in Peas and Beans. *U.S. Dept. Agr. Farmers' Bulletin, No. 1278.*—The story of the introduction and spread of pea and bean weevils is a striking illustration of the harm that may be caused by a pest of insignificant size. These beetles, which spend the greater part of their life within a single pea or bean, have been responsible for damage amounting in one province of Canada alone to over 1,000,000 dollars in a year. The fear of the pea-weevil reduced the acreage of field peas in Ontario in 1902 from 1,000,000 to 532,639 acres, and since the introduction of the broad-bean weevil to California about 1909, the acreage of Windsor beans there is estimated to have fallen 25 to 75 per cent., one former large producing area, Alameda, having practically given up the crop. The life-history of these weevils is well known; the parent beetle lays her eggs on or in green growing pods, and the grubs on hatching burrow into the peas and beans, and grow and develop there until they emerge as full-grown weevils. The rate of increase is an important factor in their powers of destruction; the female may lay fifty to fifty-eight eggs a day, perhaps about 100 in all; in the hottest weather the young develop from egg to adult in eighteen to thirty days; favourable conditions of temperature for development are afforded by the condition of the stored peas or beans, which, when infested in bulk, usually heat. The recommendations made by the U.S. Department of Agriculture for the control of the pest are: plant weevil-free seeds, harvest as soon as possible, treat to kill weevils and store where seeds can be protected from reinfestation by weevils spreading from infested seeds. Fortunately, infested seeds can be easily cleared of the pest by fumigation treatment in bulk with carbon disulphide, carbon tetrachloride, or hydrocyanic gas, or by storage in suitable degrees of heat or cold. The weevils can also be prevented from breeding in storage by mixing dust or air-slaked lime with the seeds.

The Cattle Tick in Australia. *C. J. Sanderson, Agr. Gaz., N.S. Wales., Vol. XXXIII., 1922.*—The prevalence and increase of the cattle tick (***Boophilus annulatus***) in Australia is giving rise to a situation of some anxiety. The ticks by their activities cause a nervous irritation in cattle which is immediately reflected in a decrease in the milk-yield, which in cases of heavy infestation may entirely stop, the cattle themselves are prevented from fattening, and death may occur from tick fever, hides are ruined and quarantine restrictions are made necessary. The seriousness of the situation may be judged from two of these items alone; in Queensland the monetary loss due to deaths caused by tick fever has been estimated at £7,000,000, and the decrease of the value of leather at over £10,000. Yet the author states that these disabilities could be overcome in a few months if the farmers would unite with the Government in an intensive campaign against the pest. The method of removing all horses and cattle from the pastures until the ticks have died of starvation is

impracticable, and the author recommends regular dipping with a poison dip at such intervals as to prevent engorged females from dropping and reinfesting the pasture. Dipping should continue from the first appearance of ticks in the spring till the autumn, for it has been found that a certain proportion of ticks survive dipping even when the proportion of arsenic was 12 lb. to 400 gallons of water. Ticks in the second moult stage invariably escape destruction, and have to be caught at a later stage of development.

Ants Damaging Young Trees. *H. B. Peirson, Jour. Forestry, U.S.A. Vol. XX., 1922.*—Although we are not aware that in Britain any observations have been recorded tending to show that the presence of ants is harmful to young plantations, yet the American report referred to above ought to focus attention on the matter in this country. In the Harvard Forest of Petersham, Mass., observations commenced in 1919 show a distinct loss due to the actions of the ants (*Formica exsectoides*). Wherever the ant-heaps occur the trees in the immediate neighbourhood of the nests begin to die off in an ever-increasing circle. The decay of the trees has been found to be due to actual damage done to the stem, which near the base of the tree is girdled by a narrow deep channel, resembling the work of rodents, except that the bark remains intact. The author thinks that his observations indicate that the ants kill the trees in an effort to keep their nests continually in the sunlight. That may be so, but it seems to us that a simpler explanation might possibly be that, during the hard winter weather, they find an easily obtained and succulent food-stuff in the juicy inner bark or bast of the tree stem, and its underlying woody fibre. It would appear from the observations that any tree, irrespective of its kind, may be so destroyed by ants, the only exception seemingly being that white pine over 6 feet in height is seldom killed.

Plant Foods and Human Foods in Germany. *O. Lemmermann, Zeitschrift für Pflanzenernährung und Düngung.*—Before the war Germany produced 90 per cent. of the vegetable elements and 67 per cent. of the animal products, fat, meat, milk, etc., which she required. German agriculture sufficed, therefore, for the feeding of 56 million inhabitants, and the remaining 12 million were supplied through importation, which was then very easy. The loss of 73,000 sq. km., or 13·6 per cent. of her territory, has deprived Germany of 19·7 per cent. of her potato crops; 17·20 per cent. of her barley crops; 13·72 per cent. of her rye crops; 12·60 per cent. of her wheat crops.

On the other hand, the population has diminished by 7·5 millions, or 10·8 per cent. Formerly there were 192 inhabitants per 100 hectares of arable land; at present there are 202. Larger importation is therefore necessary, a very serious problem under present conditions. Production therefore must be increased, and this can be effected by the following means:—Culture and intensified improvement of soils, proper increase of manuring, development of plantations, selection of appropriate species, selection of seedlings, control of weeds, increase and improvement of forage, etc., but the most important questions are those connected with plant and animal diseases.

During the twenty-five years of peace from 1889–1890 to 1913 the yield per hectare in Germany had increased as follows:—Bread cereals, 58 per cent.; animal feed cereals, 52 per cent,; potatoes, 56 per cent.; rye from 11·8 to 19 qx. per hectare; wheat from 15·1 to 23 qx. per hectare; oats from 14·1 to 21·9 qx. per hectare; potatoes from 101·8 to 158·6 qx. per hectare.

The consumption of fertilisers rose from 16·2 million qx. in 1880 to 106·9 millions in 1913, an increase of 600 per cent. But the war has caused a great decrease. Nitrogen, from 635,000 tons consumed in 1913 of which 185,000 were artificial fertilisers, had fallen in 1919 to 305,000 tons, of which 115,000 were artificial. Phosphoric acid, from 1,060,000 tons, of which 550,000 were fertilisers, in 1913, had fallen as low as 430,000 tons in 1919, of which 230,000 tons were fertilisers.

Consequently, the yield per hectare has decreased as follows:—

Bread cereals .	from 18·39	to 14·4	qx.	per hectare,	or 46·3	per cent.
Forage cereals .	„ 19·3	„ 15·0	„	„	„ 24·22	„
Potatoes . .	„ 142·0	„ 98·0	„	„	„ 31	„

During the last twenty-five years (1885–1889, 1908–1912), food production had increased as follows :—

Cereals	from 16·3 million tons	to 26 million tons	.	46·3 per cent.
Potatoes	„ 29·7 „	„ 44·2 „	.	48·9 „

At the same time, the increase in the population, which rose from 48 to 64 millions (300,000 yearly), was inferior by 33 per cent. to that of food production.

In order to be completely independent of importation, Germany should increase her production by 50 per cent. According to Mayer, the maximum possible yield per hectare is as follows ;—40 qx. of wheat and straw : 320 qx. of potatoes, including tops ; 300 qx. of beets, including tops.

Further, there are still 3·5 million hectares of uncultivated land which could easily be rendered arable by artificial fertilisers.

Manufacture and Composition of Milk Powder and its possible Influence on the Preservability of whole Milk Powders: *L. S. Palmer and C. D. Dahle, Journal of Dairy Science.*—Whole milk powders, if manufactured by drying a liquid film passing over cylinders, heated internally, keep much better than if they are manufactured by drying a fine spray of milk evaporating rapidly in a heated chamber. In the latter case the product has a greater tendency to become sour smelling.

The writers, believing that this difference in behaviour might have some connection with a difference in the microscopic structure of the granules, investigated the structure and found that granules of powders manufactured by the first process contained no air inside them, while granules of powders manufactured by the second process contained a small bubble of air in the middle, which was larger in the case of a spray caused by centrifugal force than in the case of a spray caused by pressure. They consider that the presence of air in the granules of milk powders of the latter type contributes largely to the fact that they are particularly liable to sebaceous deterioration, through oxidation.

Bacterial Contents of Milk Powder. *G. C. Suppler and V. J. Ashbang, Journal of Dairy Science.*—Although the bacterial contents of milk powder have probably no great influence on its hygienic value or preservability, the writers studied it with a view to obtain data to explain normal and abnormal conditions by this means. From the results obtained as a whole they draw the following conclusions :—

When the number of bacteria exceeds 1000 per gramme of powder prepared by Just's method (drying by passing a liquid film between two cylinders heated internally and turning in opposite directions), it may be assumed that, in most cases, these bacteria are derived from a fresh contamination after manufacture.

The number of bacteria in freshly made milk powder, which has not undergone fresh contamination, does not seem to depend on the number in the milk before drying, provided that the latter contains a normal flora.

Powder manufactured by Just's method normally contains a smaller number of bacteria than powder prepared by drying a spray of milk.

Bacteria in milk powder die rapidly during its preservation ; in ordinary powders manufactured by Just's method they become approximately constant after two to four months.

The presence of a large number of bacteria in milk powder produces no appreciable effect on its preservability, when the moisture is kept within the limits which make the sale of these powders possible.

LEGAL DECISIONS.

THE following case recently decided by the Second Division of the Court of Session on appeal from Lord Ashmore is of interest to agriculturists :—

Motor Cyclist and Sheep Straying on Public Road.—The Pursuer,

William Fraser, 27 Barclay Place, Edinburgh, sued Robert Pate, farmer, Walstone, Penicuik, for £250 as damages for personal injuries sustained by him under the following circumstances :—On 20th September 1922, while the Pursuer was riding on a motor cycle in daylight along the public road from West Linton to Edinburgh, two sheep belonging to the Defender suddenly rushed across the road and came in violent collision with the cycle, with the result that it was overturned and the Pursuer was seriously injured. The sheep had escaped from a field on the Defender's farm owing to a fence being out of repair, and had strayed on to the road.

Lord Ashmore, in the Outer House, dismissed the action as irrelevant and insufficient to support the conclusions of the summons, finding the Defender entitled to expenses, and his interlocutor was adhered to by the Division.

The Lord Justice Clerk (Lord Alness), who gave the leading judgment, said :—The Pursuer averred two faults against the Defender—first, defective fencing, whereby the sheep were allowed to stray from the field on to the public road, but in any event the Pursuer further maintained that the Defender was in fault in allowing the sheep to be on the road at all. The Lord Ordinary, in a very careful and elaborate judgment, dismissed the action as irrelevant, and he agreed with the conclusion at which the Lord Ordinary had arrived. The English case of Heath's Garage (Limited), 1916, 2 K.B. 370, to which his Lordship referred, decided in terms, first, that there was no duty upon the part of a defender in circumstances such as the present to a pursuer, but in any event that even if there were, the accident which occurred was not a natural and probable result of that negligence. Counsel for the Pursuer admitted as he understood, that that decision was conclusive against him, if it was sound, but he had invited the Court, for reasons which he stated, to hold that it was bad law. His Lordship had during the time at his disposal had the opportunity of looking at the judgment in question, and he respectfully agreed with the conclusions at which the English judges arrived, and also the grounds upon which they reached these conclusions. The case, as his Lordship read it, was not decided upon any specialities of English law which did not apply to Scotland, but was based upon a common-sense view of the situation—a situation which, he might add, their Lordships carefully reviewed in the light of the motor traffic which to-day takes place upon the public highways. He was unable to find any hint anywhere to the effect that the law of Scotland in this particular was different from the law of England. Counsel for the Pursuer was able, so far as he remembered, to point to only two passages which even suggested that discrimination—the one a sentence in a dissenting judgment of Lord Johnston, and the other a sentence in a judgment by Lord Benham. In that judgment Lord Benham was dealing with the case of a bull—a very different animal from a sheep ; and while it was true that in one sentence his Lordship used the word "cattle," he saw that in the sentence before and the sentence after the one in which he used that word, he carefully confined his observations to the case with which he was dealing, namely, a bull. So far from the law of Scotland differing from the law of England in this particular, he found, on the contrary, in the case of Milligan v. Henderson, 1915, S.C. 1050, mentioned by the Lord Ordinary, where a lady riding a bicycle on the public road was injured by a dog which ran out on to the road and collided with her bicycle, that the judges were at pains to state that the law of Scotland and the law of England were the same. That doctrine was fully developed in several passages. Accordingly, the law of England being clear and being fatal to the Pursuer's contention, and there being no reason why it should differ from the law of Scotland, all the indications being the other way, his Lordship had no hesitation in reaching the conclusion that the Lord Ordinary was right in dismissing this action, and he suggested to their Lordships that this reclaiming note should be also dismissed.

The other judges concurred.

STATISTICS.

PRICES of AGRICULTURAL PRODUCE and FEEDING STUFFS in March, April and May 1923.

AVERAGE PRICES OF LIVE STOCK IN SCOTLAND.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	March.			April.			May.		
	1st.	2nd.	3rd.	1st.	2nd.	3rd.	1st.	2nd	3rd.
FAT STOCK :—									
CATTLE—	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.
Aberdeen-Angus ...	67 0	62 1	44 10	66 10	61 9	44 0	66 7	61 7	43 10
Shorthorn	...	...	...	...	...	...	...	...	...
Galloway	61 10	53 9	40 0	63 5	56 0	38 0	63 2	57 7	...
Ayrshire	57 8	48 8	40 8	56 0	45 8	38 0	56 5	45 5	38 5
Cross-bred	63 4	56 11	41 1	63 6	57 6	40 6	63 1	57 5	40 8
Blue Grey	...	...	...	...	...	...	...	...	...
Highland	...	...	..	...	...	.	...	...	...
	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
VEAL CALVES	15½	7	5	16¼	7¼	5	16¾	7	5¼
SHEEP—	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds per lb. d.	Ewes per lb. d.
Cheviot	19	17¾	14¾	19¼	18½	15¾	18¼	17¼	14½
Half-bred	18¾	17½	14½	18¾	17¾	14½	17¾	17	13¼
Blackface	18½	16¾	14¼	18¾	16¾	15	17¾	16	14
Greyface	19¼	17¾	12¾	19¼	18	13¼	18	16¾	11½
Down Crosses ...	19	17¾	...	19¼	18½	..	18¼	17¼	...
PIGS—	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.
Bacon Pigs	13 10	12 7	8 5	13 5	12 0	7 10	12 8	11 0	7 6
Porkers	14 3	13 2	8 5	13 11	12 8	7 8	13 2	11 8	7 4

Average Prices of Live Stock in Scotland—*continued.*

Description.	March. 1st.	March. 2nd.	March. 3rd.	April. 1st.	April. 2nd.	April. 3rd.	May. 1st.	May. 2nd.	May. 3rd.
STORE STOCK :—									
Store Cattle—	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.
Aberdeen-Angus :									
Yearlings	18 15	15 8	12 12	18 16	15 16	13 3	19 13	16 1	12 11
Two year-olds ...	28 0	23 10	...	28 15	24 4	19 19	27 17	23 8	18 5
Shorthorn :									
Yearlings	...	..	...	..	...	...	19 15	16 0	12 0
Two-year-olds ...	...	...	...	...	...	...	28 10	24 5	18 15
Galloway:									
Yearlings	15 18	.	...	16 15		...	16 7	...	...
Two-year-olds ..	...	20 18	..	25 0	23 10	...	33 7	25 0	...
Ayrshire :									
Yearlings	...	...	.	12 0	.	..	11 6	8 5	4 10
Two-year-olds . .	. .	...	...		...	..	23 3	17 5	10 15
Cross-bred :									
Yearlings	16 18	13 14	11 8	17 16	14 15	12 19	18 0	14 19	11 10
Two-year-olds ...	26 3	21 12	19 5	28 2	23 3	20 4	27 11	22 14	18 2
Blue Grey :									
Yearlings	...	...	...	...	...	...		...	..
Two-year-olds ...	..	...	.		...	...	..	...	...
Highland :									
Yearlings	..	...	...	. .	..	...	12 6	10 15	9 10
Two-year-olds ...	...	...		...	...	...	22 7	14 6	14 3
Three-year-olds ...	..	. .	...	...	...	. .	25 15	22 12	18 9
Dairy Cows—									
Ayrshire :									
In Milk	31 16	23 17	16 5	31 9	23 3	15 4	31 9	23 15	15 6
Calvers	33 1	25 2	16 19	30 10	23 18	16 2	32 17	25 3	16 8
Shorthorn :									
In Milk	37 9	29 1	22 19	33 12	26 4	21 0	33 14	26 4	22 2
Calvers	35 14	27 17	20 2	33 5	25 9	18 6	35 5	25 17	18 7
Store Sheep—	s. d	s. d.	s d	s. d.	s. d.	s. d.	s d.	s. d.	s. d.
Cheviot Hoggs ...	64 8	47 2	38 4	65 4	53 11	43 2	61 7	54 5	41 10
Half-bred Hoggs ...	91 1	74 11	56 8	86 8	80 0	69 11	87 0	70 4	60 9
Blackface Hoggs ...	42 8	37 9	32 0	45 9	37 6	30 2	49 5	39 9	32 10
Greyface Hoggs ...	68 10	55 3	49 3	69 9	56 2	48 7	66 6	54 10	41 9
Down Cross Hoggs	...	75 0	...	96 9	79 8	55 6	...	69 2	65 8
Store Pigs—									
(6 to 10 weeks old)	56 0	42 10	...	55 2	42 4	...	51 7	37 10	...

~~AVERAGE~~ PRICES OF DEAD-MEAT AT DUNDEE, EDINBURGH, AND GLASGOW.

(*Compiled from Reports received from the Board's Market Reporters.*)

Description.	Quality.	March.			April.			May.		
		Dundee.	Edinburgh.	Glasgow.	Dundee.	Edinburgh.	Glasgow.	Dundee.	Edinburgh.	Glasgow.
		per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*	per lb. *d.*
BEEF :—Home-fed—										
Bullock or Heifer ..	1	9⅝	10	11½	9½	10¼	11⅝	9½	10	11¼
	2	9¼	9	10¼	9⅛	9⅛	10⅛	9	9⅛	10⅛
Bull	1	8⅜	8⅜	8⅜	8	8¾	8½	8	8⅞	8⅞
	2	7⅞	7¾	6¾	7¾	7¾	7⅛	7¾	8	7½
Cow	1	7⅜	6⅞	7⅞	7	7	8⅜	7⅛	7	8¼
	2	6⅞	6¼	6⅛	6⅝	6½	6⅛	6½	6	6½
Irish—										
Bullock or Heifer ..	1	...	...	10	...	...	10⅛	...	...	10¼
	2	...	...	9	...	...	9½	..	...	9⅜
Bull	1	...	...	7½	...	...	7¾	...	...	7⅞
	2	...	..	6¼	...	...	6½	...	..	6¾
United States & Canadian—										
Killed at Birkenhead	1	...	...	...	...	...	...	...	..	...
	2	..	...	...	...	...	...	...	...	...
,, Glasgow ...	1	...	...	9⅞	...	...	...	...	...	...
	2	...	...	9¼	...	...	...	...	...	...
Argentine Frozen—										
Hind Quarters ...	1	...	5⅞	5⅜	...	5¾	5	...	6¼	5¼
Fore ,, ...	1	...	4⅜	4⅜	...	3⅝	3⅜	...	3⅜	3⅝
Argentine Chilled—										
Hind Quarters ...	1	...	6⅝	6¾	...	6¼	5⅞	...	7	7⅛
	2	...	...	6⅜	...	...	5⅛	...	...	...
Fore ,, ...	1	...	4⅜	4¾	...	3½	3⅝	...	3½	3⅝
	2	...	...	4⅜	...	..	3⅛	...	...	3⅜
Australian Frozen—										
Hind Quarters ..	1	...	..	5½	...	...	4¼	...	...	4⅜
	2	...	...	4¼	...	...	...	..	..	...
Fore ,, ...	1	...	...	...	...	...	3½	..	...	3⅜
	2	...	...	...	...	...	...	...	...	...
MUTTON :—										
Hoggs, Blackface ...	under 60 lb.	17⅜	15½	17½	17¾	15⅞	17¾	16¾	15⅜	16¾
	60 lb. and over.	..	14¾	16	17	15⅛	16¼	...	14¾	15
,, Cross	under 60 lb.	17⅜	16¼	17½	17¾	16⅝	17⅝	16¾	16	16
	60 lb. and over.	...	15¼	15	17	15½	15⅝	...	14⅞	15
Ewes, Cheviot ..	1	13⅛	12¼	14¼	14¾	13⅜	14¾	14⅜	11⅜	14¼
	2	13	...	13¼	14	...	13½	14	...	12¼
,, Blackface ...	1	13⅜	12½	14	14¾	...	14¾	14⅜	...	14
	2	13	...	12⅛	14	...	12½	14	...	12
,, Cross	1	10	11¾	11¼	11¾	12⅛	12⅛	11⅜	10⅜	11⅛
	2	9	...	10	10¾	...	10¾	10⅜	...	10⅛
Argentine Frozen .	1	...	8	8	..	7⅛	6⅞	...	6	5¾
	2	...	7⅛	...	...	6¾	6	...	5⅝	5⅜
Australian ,, ..	1	..	...	6⅞	...	...	6½	...	. .	5¼
	2	...	...	6¼	...	...	5⅝	...	...	4¾
New Zealand ,, ...	1	...	...	...	...	...	...	...	...	6⅛
	2	...	...	...	...	...	...	...	...	5⅝
LAMB :—										
Home-fed	1	...	...	...	...	...	...	23	...	18
	2	...	...	...	...	...	...	...	...	16
New Zealand Frozen	1	...	12½	...	...	13¼	12⅝	...	11¾	12
	2	...	...	...	...	...	12⅜	...	...	10⅝
Australian ,, ...	1	...	...	11½	..	...	11½	...	...	10
	2	...	...	9	...	...	...	...	...	9
Argentine ,, ...	1	...	9¾	...	...	9½	...	...	9½	...
	2	...	9¼	...	...	...	...	...	...	...

Average Prices of Provisions at Glasgow.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	Quality.	March. s. d.	April. s. d.	May. s. d.
Butter:				
Irish Creamery... per cwt.	1	...	154 0	149 7
„ „ (Unsalted) „	1	...	160 0	154 0
Danish ... ... „	1	217 0	189 0	160 10
„ (Unsalted) „	1	225 0	198 0	172 5
New Zealand ... ... „	1	214 0	181 6	153 7
Cheese:				
Cheddar (Old) ... „	1	163 4	168 0	...
Cheddar (New) ... „	1	141 4	128 0	92 0
Dunlop ... ... „	1	146 0	125 6	92 0
	2	144 0	...	...
Canadian ... ... „	1	143 0	...	...
New Zealand (Coloured) „	1	153 3	138 6	104 0
New Zealand (White) „	1	150 6	142 0	101 10
Bacon:				
Ayrshire (Rolled) ... „	1	160 0	162 0	162 5
Irish (Green) ... ... „	1	126 6	132 0	126 10
„ (Dried or Smoked) „	1	146 9	151 0	142 5
„ (Long Clear) ... „	1	140 6	141 0	141 7
Wiltshire (Green) ... „	1	126 6	132 0	126 10
„ (Dried or Smoked) „	1	146 6	151 0	142 5
American, Long Clear Middles (Green) „	1	81 0	82 0	82 0
American, Short Clear Backs ... ... „	1	91 6	92 0	92 0
American, Bellies... „	1	86 0	86 0	86 0
„ Sides ... „	1	76 6	78 0	78 0
„ Cumberland Cut „	1	79 6	83 6	78 5
Canadian, Sides ... „	1	91 9	101 0	103 5
Danish, Sides ... „	1	110 0	115 0	117 10

Description.	Quality.	March. s. d.	April. s. d.	May. s. d.
Hams:				
Irish (Smoked) per cwt.	1	179 6	176 0	191 7
	2	...	...	...
American, Long Cut (Green) ... ... „	1	88 6	94 6	100 0
American, Short Cut „	1	87 9	88 6	83 2
	2	85 9	87 4	82 0
Canadian, Long Cut „	1	...	84 0	84 0
Eggs:				
Country ... ... per doz.	1	1 10	1 4	1 4
	2	1 8	1 2	1 2
Irish ... ... per 120	1	14 3	12 6	12 7
	2	13 5	11 8	12 0
„ (Duck) ... „	1	18 3	14 6	12 8
	2	17 6	13 8	12 1
Chinese ... .. „	1	10 0	9 6	...
	2	9 0	8 10	...
Danish ... ... „	1	15 5	14 6	14 4
	2	14 5	13 3	13 4
Dutch ... ... „	1	13 0	...	...
	2	...	...	...
„ (Duck) ... „	1	...	12 7	...
	2	...	12 6	...
Egyptian ... ... „	1	9 11	8 10	7 11
	2	9 7	8 8	7 3
French ... ... „	1	13 9	11 4	11 0
	2	...	10 10	...
Italian ... ... „	1	14 4	...	...
	2	13 0	...	...
Polish ... ... „	1	...	...	10 9
	2	...	...	10 6

AVERAGE PRICES OF POTATOES AT DUNDEE, EDINBURGH, AND GLASGOW.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Second Earlies.	Late Varieties. Red Soils. Lang-worthy.	Late Varieties. Red Soils. Other.	Late Varieties. Other Soils. Lang-worthy.	Late Varieties. Other Soils. Other.
		per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
MARCH.						
Dundee	First ...	...	...	...	...	2 1 3
	Second ...	...	...	...	...	...
Edinburgh	First ...	...	...	4 17 6	...	2 5 0
	Second ...	...	...	...	...	...
Glasgow	First ...	...	8 1 3	5 1 3	6 1 6	3 0 0
	Second ...	...	...	...	...	...
APRIL.						
Dundee	First ...	...	...	...	...	2 0 0
	Second ...	...	...	...	...	...
Edinburgh	First ...	...	...	4 17 6	...	2 0 0
	Second ...	...	...	...	...	...
Glasgow	First ...	...	7 0 0	5 0 0	6 5 0	2 12 6
	Second ...	...	...	...	...	...
MAY.						
Dundee	First ...	...	...	...	...	1 12 0
	Second ...	...	...	...	...	...
Edinburgh	First ...	...	...	4 14 0	...	2 0 0
	Second ...	...	...	...	...	...
Glasgow	First ...	...	7 4 0	4 12 0	6 10 0	2 15 0
	Second ...	...	...	...	...	...

Average Prices of Roots, Hay, Straw, and Moss Litter, at Dundee, Edinburgh, and Glasgow.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Roots.			Hay.		Straw.			Moss Litter.
		Carrots.	Yellow Turnips.	Swedes.	Rye Grass and Clover.	Timothy.	Wheat.	Barley.	Oat.	
		per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s d.
MARCH.										
† Dundee ...	1	...	...	17 3	135 0	...	70 8	51 11	63 2	...
	2	...	...	15 6	120 0	...	...	...	...	...
‡ Edinburgh	1	...	...	...	107 6	...	43 9	36 8	43 2	...
	2	...	...	...	92 6	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6
	2	...	...	...	...	...	...	...	...	...
APRIL.										
† Dundee ...	1	...	...	16 6	132 6	...	63 3	47 6	58 3	...
	2	...	...	14 9	...	...	...	...	...	...
‡ Edinburgh	1	...	...	...	105 0	...	40 8	...	40 0	...
	2	...	...	...	71 8	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6
	2	...	...	...	...	...	...	...	...	...
MAY.										
† Dundee ...	1	...	...	17 5	131 6	...	66 6	65 0	66 6	...
	2	...	...	15 0	120 0	...	...	...	...	...
‡ Edinburgh	1	...	...	...	106 6	...	41 0	...	41 0	...
	2	...	...	...	...	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6
	2	...	...	...	...	...	...	...	...	...

† Quotations at Dundee are for Hay and Straw baled and delivered.
‡ „ Edinburgh are for Hay and Straw delivered loose in town.

Average Prices of Feeding Stuffs at Glasgow and Leith.

(*Compiled from Reports received from the Board's Market Reporters.*)

Description.	March. Glasgow.	March. Leith.	April. Glasgow.	April. Leith.	May. Glasgow.	May. Leith.
	per ton. £ s. d.	per ton £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
Linseed Cake—						
Home	13 11 3	12 13 9	12 18 9	11 11 3	12 5 0	11 4 0
Foreign	...	...	11 0 0	...	10 15 6	...
Undecorticated Cotton Cake—						
Bombay (Home-manufactured)	7 8 0	6 13 9	6 19 5	6 3 9	6 18 6	6 9 0
Egyptian (Home-manufactured)	...	...	8 0 0	...	7 18 4	...
Coconut Cake ...	10 15 0	...	10 15 0	...	...	...
Groundnut Cake—						
Undecorticated ...	*10 0 6	10 12 6	*9 15 0	*10 0 0	*9 15 0	*10 0 0
Maize Germ Cake	10 18 9	...	10 12 1	...	10 2 6	...
Maize Germ Cake Meal	11 11 3	...	11 0 8	...	10 12 6	...
Bean Meal ...	13 1 11	13 0 0	13 1 8	13 0 0	13 0 0	13 0 0
Maize Meal ...	10 3 9	10 10 0	10 12 6	10 10 0	10 15 0	10 11 0
Locust Bean Meal	...	7 2 6	...	7 10 0	...	7 5 0
Rice Meal... ...	...	...	...	...	...	...
Maize Gluten Feed (Paisley)	9 11 3	...	9 10 0	...	9 9 2	...
Maize	†9 3 9	9 7 9	†9 14 5	9 7 9	†9 16 6	9 9 2
Oats, American ...	9 5 0	...	9 7 6	...	9 8 0	...
„ Home ...	9 10 0	9 5 0	9 15 8	9 5 0	10 5 0	9 10 0
Barley (Feeding) ...	9 3 2	9 5 0	9 5 8	9 5 0	9 8 6	9 5 0
Malt Culms ...	8 11 3	...	7 15 0	...	7 3 0	...
Distillery Mixed Grains—Dried ...	...	...	8 5 0	...	7 17 0	9 0 0
„ Wet ...	...	1 15 0	...	1 15 0	...	1 15 0
Brewers' Grains—						
Dried	8 10 0	8 0 0	...	8 0 0	...	7 19 0
Wet	...	1 15 0	...	1 15 0	...	1 12 6
Distillery Malt Grains—Dried ...	8 13 9	...	8 8 9	...	7 16 6	...
Wheat—						
Middlings (Fine Thirds or Parings)	9 2 6	8 8 9	9 5 0	8 8 2	8 12 0	8 2 6
Sharps (Common Thirds)	8 5 0	7 14 2	7 18 9	7 18 2	7 3 0	7 10 0
Bran (Medium) ...	8 11 3	8 5 0	8 6 3	7 13 9	7 2 6	6 19 0
„ (Broad) ...	8 16 3	...	8 11 3	8 5 0	7 10 6	8 1 0
Feeding Treacle ...	5 10 0	5 11 3	5 10 0	5 15 0	6 19 0	5 17 9
Fish Meal... ...	15 15 0	15 10 0	15 15 0	15 10 0	15 15 0	15 10 0

* Oil and Albuminoids 40 to 42 per cent.
† American Corn.

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AGRICULTURE AND STATE INTERVENTION.

A PRELIMINARY SURVEY.

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THIS is neither a propagandist nor political contribution to the pages of the *Journal*, but chiefly a chronicle, by no means complete, of the earlier troubles of the agriculturist, and of certain legislative efforts towards amelioration.

Effects of War on Current Views.—During the years of war belligerent peoples became familiar with the bureaucratic control, and even with the maternal nursing of certain industries. The strain of national crisis put the doctrines of supply and demand, and *laissez faire*, completely out of fashion. Most of us ultimately recognised the need for loyal submission to an autocracy in all things relating to the production, distribution and use of things essential to the conduct of military operations, and the preservation of the nation's life. Before the end came the word "commandeer" was almost as over-worked as "camouflage," and there are many who believe that had the electors been ready in August 1914 for the immediate and universal application of the word "commandeer," and of its kindred word "conscription," a military victory would have been won long before the month of November 1918. That, however, proved politically impossible, and so the agriculturist found himself taken, so to speak, to the heart of government, fostered and cherished for the nonce as a new found friend of the State. Nothing could be more significant in the military tribunals of 1916 and 1917 than the gradual change of attitude towards agriculture. At the outset, the War Office and the Board waged an incessant warfare for the possession of men, until at length it was recognised that the nation's manhood was as much required in the one sphere as in the other. Then the tragic argument of the submarine finally settled the national policy:—agriculture must not only be preserved, but rapidly developed. To the clamant need for development, the rules of economic science gave place. The public mind was so impregnated in these years of stress with this conviction as to the national value of tillage, that, in spite of a general desire for as speedy a return as possible to pre-war

conditions, the great majority of the electorate are ready to accept as inevitable a continuance of maternalism, so far as agriculture is concerned. Food, and shelter, and health have come to be recognised as directly concerning a Cabinet in time of peace, just as much as the manufacture of munitions in time of war. The centre of political gravity shifted soon after August 1914, and never again will find itself at the old spot. To attempt to arouse electoral interest in old party shibboleths will be like flogging dead horses. The result is a still further change in public feeling with regard to the State control of agriculture. For in relation to these three national objectives, plentiful food, sound public health, and adequate shelter, agriculture holds, unchallenged among the industries, the premier place.

The Antiquity of State Concern.—This concern for the welfare of agriculture has been so marked a feature of recent politics that many are apt to regard it as a sequel to the great war. Its direction has been changed, and it has received a mighty impetus from the conflict—nothing more. Its origin is not found in the years which succeeded the Napoleonic struggle, although these years add weight to modern opinion. Still less does this public concern begin with the legislation of the early eighties of last century, although the year 1883 may be said to have seen the first genuine parliamentary effort towards a constructive agricultural policy.

Early Evidences.—One or two inconsequent observations will serve to show how remote in time are the earliest evidences of national concern for agriculture. It was certainly a prevalent idea among ancient peoples that the land, of which a State physically consisted, except in so far as it was devoted to public purposes, should be divided equally among its citizens. Moses assigned a portion of land to each man, the assigned portion becoming inalienable property, and descending to the allottee's heirs. The main purpose of the division may have been the maintenance of equality, but it seems clear also that a secondary object was to secure the efficient cultivation of the soil. About 600,000 Israelites entered the land of Canaan; to each was assigned, it is said, from sixteen to twenty-five acres; the creation of debt permanently affecting the land was rendered difficult, if not impossible, by the prohibition of usury; diligent and skilful cultivation was encouraged, and the soil became productive in a very high degree. In much later days we read of the seed being multiplied some thirty, some sixty, and some an hundredfold.

It is interesting to note also that laws were passed to regulate the occupation and use of the public lands of ancient Rome. As early as the fourth century B.C. it was decreed that more than 330 acres of public land should not be possessed by one person, that the holder must employ a certain specified amount of free labour in the cultivation of the land occupied, and that only a certain number of cattle were to be grazed on the public lands thus held. The idea underlying the last named rule was the same as in

more modern times,—to prevent the farmer devoting his holding wholly to pasturage, to the exclusion of the more strenuous, and perhaps less profitable, tillage. These early rules were apt to be more honoured in the breach than the observance. Doubtless the powerful patricians contrived to hold more than the law allowed, and the plebeian small holders tended to disappear; but the significance of the law is unaffected. Nor did the ancient Egyptians allow the agriculture of their country to take care of itself. It was believed by them also to be inexpedient to permit the control of large tracts of land to fall into the hands of individuals, and elaborate provision was made for restriction of the size of holdings. In short, the introduction of a system of small holdings, as a means towards the development of agriculture, is not an idea of this or last century, but of the centuries before the Christian era. It is coeval with the rationing system—the patriarch Joseph, being, as everyone knows, one of the earliest food-controllers.

Scottish Evidences.—In the first centuries of the Christian era in Scotland, agriculture was neglected. The crude and unreliable governing authority took little or no interest in it. The great majority of the people themselves had no share in the cultivation of the soil. Such cultivation as there was remained for long in the hands of a very few. The rest of the people were savages, clothing themselves in skins, living in caves, and subsisting on the spoils of the chase. In the early middle ages agricultural lands were held by the Sovereign, the greater barons, and inferior nobles. No doubt a certain amount of tillage was performed by the bondsmen and serfs of the nobility; and out of this there gradually developed a primitive system of tenancies and leases recognised by the Sovereign, and his coadjutors. But so long as the barons were more interested in laying waste their neighbours' lands than in cultivating their own, and so long as government remained, as it did for centuries, virtually in the hands of the barons themselves, the systematic enclosure of lands, for purposes of cultivation, was too much to expect. The best that could be looked for, and the best that was found in the midst of interminable strife, was a belated recognition by the barons of the value of cultivation, and a permission to certain of their vassals to till patches of land, first as baronial servants, and later as quasi tenants. To begin with, the consideration for such permissions took the form of services rendered to the lord and his household; later, a certain proportion of the products of the soil was delivered to the owner thereof; and, lastly, money rents were paid. For long there was nothing remotely resembling security of possession, and certainly nothing in the nature of a binding contract, as between owner and lessee, under the aegis of a settled and impartial government.

Early Leases.—It is believed that as early as the thirteenth century there were in England leases of land for agricultural purposes for a life or a series of lives, or for a period of years. The same is thought to be true of Scotland, where tenancies were permitted for determinable periods, for service, produce, or money

rents, about the same period. Even these, however, were not as has been indicated, contracts in the sense that a nineteenth century lease was a contract. They were in the earliest times, as at present, described as "grants." The word suggests what was then truly meant—a permission or privilege conceded by a superior to an inferior. It is interesting to note that the word "grant" remains in use to this day, long after its real significance has disappeared. It is also interesting to contrast the legislative aid given to the tiller of the soil in the fifteenth, with that given in the twentieth century. In the former, one notes the gradual evolution of a binding contract; in the latter, one has grown accustomed to see Parliament refusing effect to a contract between a landlord and tenant, in the interest of the latter, as well as in the public interest.

Security of Tenure.—Prior to the year 1449 leases were, as I have noted, frequently granted by an owner to a tenant for a series of lives, or a period of years. The law was such that when a change took place in the ownership of subjects let, at all events when the new owner was not the heir of his predecessor, the tenant, having in strict law no contract with the purchaser, was liable to be removed from his holding. This was, of course, utterly inequitable, except on the assumption that the tenant was no better than a bondsman or serf. It was at the same time totally inconsistent with agricultural development in any modern sense. So parliament, in a flash of enlightenment, declared in language which may be rendered in modern English thus:—"Also it is ordained for the safety and favour of the poor people who labour the ground, that they and all others who have taken or may take lands in time to come from lords, for a definite number of years, in the event of the lords selling or alienating the lands so taken, the tenants shall be entitled to remain in possession under their tacks, till the issue thereof, at the rent stipulated for in the tack, it matters not into whose hands the lands may come." Even the phraseology is significant of the mental attitude of the legislature. The enactment was no more than a gracious concession to "poor people" without rights. Yet it was a step in the same direction as several others taken nearly five centuries later. The rule of that fifteenth century statute has become a mere commonplace of our law, so much so that many do not realise that it depends for its authority upon an Act of Parliament, just as fully as the twentieth century rule against "unreasonable disturbance."

Liability for Landlord's Debts.—The farmer of that period suffered from injustices even more flagrant. Living in the twentieth century it is hard to believe that until 1469 a tenant might, in practice as well as in theory, be liable not only for his own debts, but for those of his landlord. In those times the landlord made the law, and it is perhaps to his credit that, even in the fifteenth century, his eyes were beginning to appreciate points of view other than his own. A cynical person has said that for many

centuries the earth was the landlords' and the fulness thereof, meaning not only the earth, but all that grew or rested thereon. The right of a creditor to seize the land of his debtor, and by legal consequence everything on the land, whether the property of the landlord or not, was a legal principle well established long before the year 1469. In practice this might, and did, mean that if A, a landowner, happened to be due £1000 Scots to B, his creditor, B might seize the rude implements and stocking of C, the tenant of A, without any reference whatever to the state of C's indebtedness to A. Even a moderately progressive agriculture under such a rule was, without doubt, an impossibility. With complacent satisfaction borne of a sense of their generosity to the "poor men inhabitants of the ground" the legislators of 1469 enacted :—"Also to eschew the great hardship and destruction of the King's Commoners, tenants and dwellers on lord's lands, through the operation of legal diligence, where judgments are pronounced for sums of money against the lord—the owner of the land—the goods and cattle of the poor men, the inhabitants of the ground, are taken and distrained for their lords' debts, even where the rent is not as much as the amount of the debt, it is advised and ordained in this present Parliament that from henceforth poor tenants shall not be distrained for the lords' debts to a greater extent than the amount of the rent, etc." This has been interpreted as meaning that a tenant's goods cannot be seized for a debt of his landlord, except to the extent that the rent is in arrear. These reiterated references to "poor tenants" and "poor inhabitants of the ground," and the need for such a measure as that of 1469, testify to the miserable state of agriculture in the fifteenth century, and yet suggest that a new day was beginning to dawn.

Purveyance.—In spite of the miserable conditions of these "poor inhabitants of the ground" they were subjected to cruel exactions throughout the fifteenth and sixteenth and even seventeenth centuries. The levy of the Great Purveyance, fortunately more familiar in England than in Scotland, by which was meant the obligation of the farmer to supply, at current prices, the King's armies and houses in time of war with provisions, carriages, etc., was in itself a crushing burden. Even more intolerable was the Lesser Purveyance, under which the tenants of the King's lands were compelled to provide, free of charge, the provisions required by the King's household when he travelled through the kingdom. The barons and great nobles were ever ready, in such a matter, to follow the King's example, and the poor inhabitants looked to the law in vain for remedy. Statutes were passed from time to time to restrain, or at least regulate these iniquitous exactions, but it was not till the beginning of the seventeenth century that a sense of justice prevailed, and agriculture was for ever freed from so intolerable a burden.

The Drawing of Teinds.—For Purveyance it may at least be said that the burden was occasional. The injuries inflicted by

the titulars or owners of the teinds, ecclesiastical or lay, upon the harassed farmer were experienced as regularly as harvest came. Teinds were generally speaking of two kinds, parsonage and vicarage. With the latter, the minor teinds, I do not concern myself. But the parsonage teinds, *i.e.*, the tenth sheaves of grain, were, as late as the 17th century, regularly "drawn" or uplifted by the titular from the fields of the cultivator during harvest, "led" from the fields, and stacked. No doubt the cultivator's rent was fixed partly with reference to this right of the teind owner, but the method by which the right of drawing teind was enforced was inevitably injurious to the tiller of the soil, and was often exercised in a way which caused not only inconvenience but great loss to the farmer. The law as it originally stood forbade the farmer to secure his crops till the tenth sheaves were "drawn." If he attempted to do so, in order to save his crops from destruction, he was liable in damages (spulzie) to the titular. In 1579 the legislature tenderly intervened on behalf of the "poor labourers of the ground," and provided that those entitled to teind the corn should do so within eight days after shearing, and if they failed timeously to "draw" the teind, the farmer might himself do so in presence of two witnesses, but only after intimation in the parish church for three Sundays. If sixteenth century weather was similar to that of the twentieth century, one might well ask what happened to the "Corns" in the interval.

In 1587 a more venturesome parliament decreed that the intimation might be reduced to two Sundays. Then the Act of 1606 provided that the teind sheaves might be drawn and stacked by the farmer himself at three different times—"infield" corn at one time, "bicr" at another, and "outfield" at a third; but a fifteen days' requisition had to be presented to the titular to "draw" within seven days after the expiry of the fifteen. The fifteen days were reduced by statute to eight in 1612, and to four in 1617. The Act of the last named year provided, however, that the farmer must preserve the teind sheaves for eight days after he had drawn them. All these enactments surely provide the student of history with a unique example of legislative timidity, and an incomprehensible inability, on the part of the governing class, to appreciate the disastrous effects of such a system on agricultural development. In this connection, however, the great power of the church must be remembered, and that the titulars of the teinds were frequently the bishops of the pre-reformation church, or the heads of one or other of the many religious houses which flourished in Scotland.

It was only indirectly that the grievances of the cultivator associated with teinding ultimately disappeared, as a result of the tardy interference of parliament. In 1633 an Act was passed providing for the valuation of teinds as a basis for settlement with the titular. After valuation actual "drawing" was not permissible. Valuation has not been universal, but under its influence the practice of "drawing" the teind, utterly obnoxious as it was alike

to the individual farmer and to agricultural interest generally, fell gradually into disuse. A well-known authority on the subject, writing in 1892, says that in his time he had only heard of one small piece of land where drawing of the teind had taken place in recent times.

Entails.—Early agricultural grievances were as a rule associated chiefly with ancient customs or common law conditions, but the next in the catalogue was the creation of parliament itself. The seventeenth century saw statutory sanction given to a system inimical in the highest degree to agricultural development, a system which later parliaments were compelled slowly to modify in the public interest. The object of the Act of 1685, promoted and passed by the Lord Advocate of the day—Sir George Mackenzie, more familiarly, if not more appropriately, known as "Bloody Mackenzie,"—was doubtless to preserve noble families in close association with large estates. The public interest in land seems never to have occurred to those responsible for the measure, or to have been completely obscured by its main purpose. Compliance with the terms of the statute entitled an owner of land to settle it on a prescribed series of heirs—heirs other than the owner's heirs-at-law. From the point of view of agricultural development it is important to note that every deed of entail, in order to settle land on such a prescribed series of heirs, had to include three essential prohibitions, generally referred to as the "cardinal prohibitions." The first of these prohibited an alteration in the order of succession, the second any alienation of the estates from the heirs specified, and the third the burdening of the estate with debt. Looking with more enlightened eyes at these prohibitions, and especially at the two last, one can see how completely they tied the administrative hands of the heir in possession of land. He could not sell any part of it, however much that might be in the interest of the estate as a whole. He ceased to have a personal interest to effect permanent improvements on the estate for the sake of sound agriculture; and the Act prevented him from raising money with which to do so, when he happened to be sufficiently disinterested to think of improvements. However obvious this may appear to us, eighty-five years had passed before parliament took the first step towards freedom of administration for the heir in possession of entailed lands. In the year 1770 there was passed the Montgomery Act, which, after a preamble of great significance, directing attention to the public advantage to be derived from encouraging an owner to make improvements on his land, such as drainage, the erection of farm houses, farm buildings, and the like, gave him power to execute improvements of the kind contemplated by the statute, and to charge a certain proportion of the cost on the estate either by way of bond of annual rent, or bond and disposition in security. It is the general tendency of this piece of legislation, and the recognition by parliament of a public duty towards agriculture, which is important rather than the details of the measure. The eyes of

government having been opened, the movement became steadily progressive. In 1848 the Rutherford Act was passed which still further increased the power of the heir in possession in relation to the making of improvements, and the creation of burdens on the land to facilitate these. In 1882 the sale of a portion of entailed lands for the purpose of meeting the cost of improvements became competent; and the Agricultural Holdings Act of 1883 provided, it will be remembered, for making the sum payable by a landlord to a tenant for improvements, strictly agricultural in character, chargeable on lands—thus indicating clearly the view which the legislature had at length reached, that the preservation of landed estates in the hands of a family, however advantageous from one standpoint, must be subordinated, in the national interest, to a sound and prosperous agriculture. Alongside of this general current in favour of freedom of administration there had been recognised, and steadily extended, a right on the part of an heir of entail in possession to disentail the lands, at first with elaborate consideration for the interests of subsequent heirs, and later without any consents, provided the approval of the Court of Session could be obtained to the disentail. There can be no doubt that this legislative movement towards the liberation of heirs of entail in possession was dictated, not so much by consideration for the heirs themselves, as by the public interest in their greater freedom. And now, when discussing this question of entails, I remind my readers that at length the parliamentary point of view has turned full circle, for parliament in 1914 declared the constitution of new entails to be illegal. Thus there is presented to us, as we survey the matter from the point of view of agricultural development, a striking instance of a great legislative blunder committed in the year 1685, thoroughly detrimental to progress, and seen to be so, yet only remedied by timid, hesitating efforts separated as a rule by long periods of years. In legal terminology one speaks of the fetters of an entail. How much to be regretted it is that so many years passed without parliament realising that these "cardinal prohibitions" of an entail were fetters shortening and impeding the steps of agriculture, and thus inflicting profound and far-reaching injury upon the people.

Apart from the legislation directed towards the loosening of the fetters of strict entails, there were statutory provisions for exchequer grants to owners of lands for the development thereof, especially in the middle of the nineteenth century, such as the Drainage Acts of 1846 and 1849, and the Improvement of Land Act of 1864, but these were to a considerable extent rendered necessary by the statutory sanction still lent to the creation and preservation, in fact as well as in theory, of strict entails.

The Corn Laws.—At this point I direct attention to certain parliamentary attempts to intervene in the interest, or supposed interest, of the agricultural community from a somewhat different angle. It will be remembered that until the end of the eighteenth century Great Britain was not only self-supporting, so far as

regards grain products, but was even an exporter of grain. But it must be remembered also that the population of Great Britain was at this period only about five millions. Then there came a more or less rapid rise in the population of the country, and new national problems emerged. For with the rise in the population, the grain requirements of the people rose above the level of their productive capacity, and foreign grain had to be imported. The thought of the grain needs of Britain being supplied to any extent from external sources was shocking to the landed interest. They foresaw the possibility of falling prices, and emphasised the need for preserving the country's chief industry. The preponderating control which landowners still exercised in the government of the country had, of course, an important bearing on government action. There can be no doubt that the land-owning class, during the last half of the eighteenth and first quarter of the nineteenth centuries, urged the control of the importation of foreign grain out of fear for the depressing effect which foreign competition might have on the rents obtained by them; and they succeeded in obtaing the support of the tenant farmers of that day by dwelling on the possibility of such a fall in prices as would ruin the tenant. The farm labourer too, so far as his support was of any moment at that date, gave it because he trembled at the thought of reductions in his already miserable weekly wage.

But legislative interference with the axioms of economic science have never been openly defended on grounds of hardship to the owner, or farmer, or tiller of the soil. A few random quotations from the utterances both of those who favoured legislative interference with the price of grain, and of those who opposed it, make clear that all felt it necessary to ignore the individual interest and lay the stress on the public concern. Sir James Graham in 1839, in opposing the then annual motion of Mr Villiers for the repeal of the Corn Law, as Lord Morley tells us, spoke "of the neat thatched cottage, the blooming garden, the cheerful village green. The repeal of the corn laws would lead to a migration from all this loveliness to the noisy alley, and the sad sound of the factory bell. Tell me not any more of the cruelties of the conveyance of the Poles to the wintry wastes of Siberia. Talk not to me of the transportation of the Hill Coolies from Coromandel to the Mauritius. A change is contemplated by some members of this House far more cruel, far more heartrending, in the bosom of our native land." This sounds high-falutin in modern ears, but it shows clearly the basis of the defence of the Corn Laws. Similarly, Sir Robert Peel, about the same date, told the House of Commons—"I have no hesitation in saying that unless the existence of the Corn Law can be shown to be consistent not only with the prosperity of agriculture, and the maintenance of that interest, but also with the protection and the maintenance of the general interests of the country, and especially with the improvement of the condition of the labouring class, the Corn Law is practically at an end." Mr Cobden himself was not more

disinterested in attack than Sir Robert Peel and Sir James Graham were in defence, for he believed that repeal and the free importation of foreign grain were essential to the steady development of the manufacturing industries of Great Britain, in which he had a keen personal interest. We find him using language which Sir Robert Peel might have adopted as his own. "It is," he said, "the condition of the nation, and not the interest of a class, or the abstract doctrines of economics, that cry for a relief which it is in the power of the legislature to bestow." It is also interesting to remember that Cobden himself put into words one of the chief arguments of those who would maintain agriculture in prosperity, even in defiance of every economic law. In effect he declared that the manufacturing population of a Lancashire town must, if it is to survive, be renewed every third generation by an infusion of vigorous rural blood. Yet it is certain that both Mr Cobden and Mr Bright, judged by their unsympathetic attitude to the ameliorative factory legislation of Lord Shaftesbury, would have declined support to each item of agricultural legislation from the year 1880 onwards as wholly unwarranted interferences with the sacred law of supply and demand.

However mistaken may have been the corn law legislation of the years 1773, 1815, and 1828, the ideals behind it always ostensibly were—home produce of grain sufficient to support the whole population, not only in time of war, but also in time of peace, a contented and prosperous agricultural population, always providing the necessary brawn, bone, and sinew to the whole nation.

As props to a tottering industry adventitious aids, whether in the form of bounties on exportation or of graduated or fixed duties on imported commodities, were alike unavailing. These, as operated in the first half of the nineteenth century, were at once a serious injury to industry in other forms, and a menace to the poorer sections of the community, whose food supply at moderate prices was endangered, without conferring substantial advantage on the agriculturist. In whatever form these aids were presented they were alike futile, whether, in the case of the legislation of 1773, as a bounty on exported wheat of 6d. per quarter, when the home price was at 48s. per quarter, or as a prohibition of any importation of wheat unless the home commodity had risen to 80s. per quarter, as was provided in the Act of 1815, or the imposition of an import duty, varying inversely with the price of grain in the home market as contemplated by a Corn Bill introduced in 1827, and as enacted, with even more haphazard variations, by the Duke of Wellington's statute of 1828. This last provided that, when the price in the home market was 64s., the duty on imported wheat would be 23s. 8d. per quarter, and when the home price touched 73s. per quarter, the duty would automatically fall to the nominal rate of 1s. per quarter. It is not necessary to denounce all these impositions as selfish, unpatriotic, or the like. Uneconomic they certainly were, but

to-day statesmen are not convinced that Burke was wholly right in 1773 when he fulminated against the artificial separation of the landed interest from the trading interest, and declared that he who separated the interest of the consumer from that of the grower starved the country; or when, many years later, he described as mischievous and futile a system which sought to deal with agriculture as if it were different from any other branch of commerce.

The overwhelming majority of the people of Great Britain were convinced within ten years of the repeal of the Corn Laws, following on the historic conversion of Peel in 1846, that a panacea for all the ills affecting agriculture was to leave it alone. There is, however, no lesson more frequently learned from a study of national history than that a political judgment is never final. Before many years have passed it will be subjected to review and modified, altered, or even reversed; and so within thirty years of the repeal of the Corn Laws politicians and people were alike beginning to doubt whether parliament could dare to leave agriculture to take care of itself, and to wonder whether, even if the re-enactment of the Corn Laws might be politically impossible, interference might not find another channel, just as inconsistent with the doctrine of *laissez faire*, and cutting even more deeply into the individualism so dear to the hearts of Cobden and Bright, and their colleagues of the Manchester School.

The Richmond Commission.—In eras of prosperity, whether wholly natural or in part artificial, as in war years, even such an industry as Scottish agriculture may be trusted to live and flourish; but in normal times, and especially when the industry has been threatened by a great depression, the need for parliamentary care and control is everywhere recognised. The first three-quarters of the nineteenth century had been characterised by a pendulum of prices, but in the late seventies a period of profound depression followed an era of comparative prosperity, and the governing mind once more realised the need for taking a hand in agricultural affairs. The Richmond Commission deliberated, and solemnly came to the conclusion that the lamentable fall in prices was due almost wholly to foreign competition. The members of the Commission apparently thought that American wheat could not be imported into Great Britain at less than 49s. 9½d. per quarter at Liverpool, and accordingly that melioration in agricultural conditions at home would suffice to restore prosperity in the industry. There would of course be continued fluctuations in prices, but always within the safety mark of 49s. 9½d. The ameliorations would put an end to rural depopulation and urban congestion, and once again the country districts would renew the life blood of cities. Even that momentous reduction of five million acres in the cultivated area of the country would cease to be progressive. The men who had left the land would return to it, and those who were on it would remain, encouraged to return and tempted to remain by the alluring prospect of hundreds of State established and

aided small holdings. But the chief practical conclusion of this Commission was that the demand of a tenant farmer for a legal recognition of his right to compensation at the end of a tenancy for all improvements executed on the holding at his own cost was righteous, and that a denial of this claim meant the penalising of the best tenant by the confiscation of his improvements.

Before attempting to deal, as I hope to do later, with the Agricultural Holdings Act of 1883, and the series of enactments culminating in the Statute of 1923, which have completely altered the outlook of the landlord, the farmer and the labourer, I would like, in concluding this article, to refer briefly to other two subjects which fall naturally within that earlier series of statutes devoted mainly to the remedying of incidental grievances. The first of these may be considered under the heading:—

Landlord's Security for Rent.—Here again it is the early point of view of Parliament which is significant. A Statute of the year 1555, entitled an "Act anent the warning of tenants," was framed certainly not with the idea of giving security of tenure to the tenant, but of enabling a landlord to get rid of one with promptitude and without hitch. And there breathes throughout the famous Act of Sederunt anent removings of 14th Debember 1756 the determination of its framers to see that a tenant in financial difficulties would as speedily as possible cease from troubling. No doubt the preamble of this Act of Sederunt narrates,—"the difficulties that have occurred in actions of removings from lands which have been found highly prejudicial to agriculture, both to masters and tenants, in respect that during the dependence of such actions the lands are neglected and deteriorated by the defender, *and the heritor's security for his rent brought into danger*, and tenants are discouraged from entering into tacks by the uncertainty of their attaining to possession, and by thus finding the subject of their tack much deteriorated during the dependence of the process of removing against the preceding tenant." The spirit of this legislation is apparent. While paying lip service to the needs of agriculture, there is care for the "masters," anxiety as to the safety of their rents, and the deterioration of the soil for the masters and their incoming tenants, and not one thought for the existing tenant, or the possibility that he also may have rights calling for fair consideration and protection. The language of the enacting clauses tells of a determination to provide machinery whereby tenants with or without written tacks are to be got rid of at the end of their tenancies; of the evil fate of sub-tenants who may have taken possession with an owner's tacit, if not active approval, and yet must quit without remedy on notice to and proceedings directed against the principal tenant only; of tenants in arrear and orders against them to get out or to pay, and find security for future rent to such extents as made the privilege of purging the irritancy no better than a mockery. Had the franchise been less restricted, it would not have required one

hundred and twenty-five years for the legislative wind to veer from the crude yet fiercely effective provisions of the Act of 1756 to a partial appreciation of the tenant's standpoint, expressed in the "Act to Abolish the Landlord's Right of Hypothec for Rent in Scotland" of the year 1880. Till that Act was passed the landlord held by force of law all the tenant's implements, stocking, etc., as a security for his rent, and could, if the tenant were even in temporary financial trouble, bring him to his knees by seizing these for payment of arrears of rent and the rent of the current year, thus leaving the tenant's unsecured creditors to scramble for anything which might remain after the satisfaction of the landlord's claim. Without the fund of credit provided by the farm stocking the tenant's position as a trader was difficult indeed. This reform was long overdue, and there were other clauses in the Act just as significant of the governmental change of attitude to the agricultural tenant. While on two minor points increasing the stringency of an owner's right to eject, the Act effectually took away with one hand what it gave with the other, for it reserved to the tenant in arrear with his rent the privilege of a way-going tenant, a further right to be compensated for labour expended on the farm to the date of removal, and also ended liability for rent as at that date. There is no clause prohibiting "contracting out" in this Statute, but in effect landlord and tenant could not contract themselves out of it, because the rule of our common law is that a creditor cannot obtain a security over movables which remain in the possession of his debtor. Accordingly, the right of hypothec having been abolished by statute, the parties could not, however willing they might be, create by agreement a security for rent over the tenant's movables.

Ground Game.—Many of us can understand even if we cannot fully sympathise with the jealous regard of landlords for their rights in relation to the game on their estates. These rights, it is no exaggeration to say, constituted a hallmark of social distinction for centuries prior to the year 1880, in which year was made the first successful parliamentary assault in the interest of agriculture, on strict game preservation. Before the passing of the Ground Game Act of that year a tenant was entitled at common law to destroy rabbits on his farm to protect his crops. To hares the common law gave him literally no rights. But observe that even with regard to rabbits he might make such a bargain with his landlord as would deprive him of right to destroy them. It is quite true that before the passing of the Act a tenant was entitled to compensation for damage caused by an undue increase of the stock of game. But to enforce the claim against a resisting landlord meant litigation, and litigation inevitably meant a disturbance of those friendly relations which every prudent lessor and lessee desired then and still desire to maintain. A love of fair dealing in both led in most cases to an amicable adjustment of claims. On the other hand, there were undoubtedly many cases in which tenants and agriculture generally suffered grievously

through inequitable game preservation. The result was the Act of 1880, important in part as an attempt to remedy an ancient grievance, in part as a considerable lopping from the tree of privilege, and still more as indicating a further change in the attitude of the State towards agriculture. An attempt may be made to sum up the effect of the Act thus:—Every tenant farmer may kill hares found on his holding. This right to kill hares conferred by the Act, and the former right of the tenant to kill rabbits, cannot by any contract with the landlord be bartered away. Restrictions were, of course, placed on this new right. For example, the tenant might himself kill by firearms both hares and rabbits, but only one other person authorised by him could do so, and that person must be either a member of his household, a servant, or a person *bona fide* employed for reward. Such persons and the farmer himself might also kill by other legal means. Killing at certain times and by certain means were declared illegal; as to time, between the expiration of the first hour after sunset and the beginning of the first hour before sunrise; as to means, by setting traps, except in rabbit holes, and by poison. But these prohibitions apply to all who are entitled to kill ground game, and in this respect the landlord has no higher privilege than the tenant. The amending Act of 1906 made certain restrictions with regard to time and manner of killing ground game in the case of moorlands and unenclosed land, but these details are not important. Nor, for the present, shall I dwell on the new and far-reaching rights conferred on tenants by the Act of 1908 in relation to damage done by winged game. The chief points of interest for me are (first) the stern prohibition in the principal Act of any attempts to contract out of it, illustrated strikingly by the fact that even a landlord, who farms his own land, cannot by any bargain deprive himself of his right to kill the ground game on the farm, and (second) the terms of its remarkable preamble, indicating that the eyes of statesmen and politicians were at length fully opened to the true national attitude towards agriculture:—"whereas it is expedient in the interests of good husbandry, and for the better security for the capital and labour invested by the occupiers of land in the cultivation of the soil, that further provision should be made to enable such occupiers to protect their crops from injury and loss by ground game."

Evolution not Revolution.—Similar words might well preface any measure of agricultural reform. As will be seen these Acts of 1880 were the forerunners of a new era, the characteristic of which will be found to be the gradual development in the national interest of a tenant right in land, difficult of equitable regulation, whose final issue it is not yet possible to foresee. But if the process be one of sane evolution and not revolution, I do not think that any one interested directly or indirectly in agriculture or anyone anxious as to the political future of his country has anything to fear.

STANDARDS OF PRODUCTION AND NET OUTPUT ON SCOTTISH FARMS.

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THE standards by which the production of any system of agriculture are judged are of the greatest importance to agriculturists, yet they are often little understood, and some of the standards which are applied are both misleading to the public and of great danger to the agricultural community. In times of peace on the farm the farmer is chiefly concerned with the profits which he obtains, and judges the system of farming which he undertakes by his total income or by the rate of return on his capital. The most piping times scarcely yield profit enough, but peace is always liable to disturbance by other human elements concerned. Often the employees' standard of judgment of results has to be taken into consideration, and then the system of farming has to be judged partly by standards which are directly connected with their interests. The rate of wages per person which it is possible to pay under the system may then be applied as a test of the results of the system, or in times of general industrial depression the test may be the total amount of labour per 100 acres of land for which the system provides employment. Social reformers are liable at any time to apply the latter test because of its apparent connection with the maintenance of the health and physique of the nation. There are also persons who will combine these two tests of a system of farming and inquire what is the total amount of wages of labour provided by any system. The owner of land will judge the results of a system of using his property by the rent it will yield. In times of marked prosperity of agriculture he is particularly apt to apply this test, and in times of depression he is often forced to consider it by the action of his tenant.

Here are three tests of the standard of production of any agricultural system which are related to the positions and functions of the three human factors involved. Used alone each of these gives only a limited result, which is more directly connected with the division of the product of the system than with the amount of the product itself, although eventually neither can be used without reference to the amount of that product. When combined, these three tests provide a standard of judgment for the whole of the agricultural community, which is of the greatest importance. The contribution of the owner's land and improvements, of the farmer's capital and directive activities, of the workers' energy and intelligence are always necessary to production. Their remuneration for the respective contributions is determined by the net results of their use on the farm. Between them the owners, farmers and workers control the whole of the organisation.

They buy raw materials from outside the group and from outside the fences of the farm on which their contributions are expended. These raw materials are purchased on contracts which, normally, have to be fulfilled without reference to the results of their use. The result in value of product which is available for distribution between the three human factors is the net amount of the sales of the farm after the raw materials have been paid for. For convenience this has been called the "net output" of the business. It is ascertained by taking the total sales of produce of the farm and deducting the cost of materials such as feeding stuffs, seeds, fertilisers, etc., which are obtained from outside the group. This net output represents the results of using the owner's land and improvements, the farmer's capital and energy and the worker's energy, in the system of farming followed and under the form of organisation which is adopted. It is the result of their contributions to production And irrespective of the manner or the justice of the distribution, and under temporary circumstances, the amount of the net output is of the greatest importance not only to the whole group but to each section of the group, for it determines the limits of possible incomes.

It may be said that the farmer is the only person concerned with the net result of production, for he obtains the use of the land on contracts which he must fulfil, and that these contracts often run for considerable periods of time. Also that he obtains labour on contracts, weekly, monthly or yearly, which must be fulfilled without reference to results. But the simple acceptance of these facts and the application of them to the position over any considerable period of time leads inevitably to the conclusion that the only net product of the industry that matters is the profit received by the farmer. This is not true, and the application of such a conclusion can never give practical working results. In the long run, and even over a few years, the rent received by the owner of land is determined by the net product of the industry rather than by the contract, and the estimates upon which the temporary contract is based are made upon the amount of the net output. The workers' position, either in rate of wages or in amount of employment, is immediately affected by any change in the value of net output, and, in the long run, is entirely determined by this.

Although there is no precise method of measuring the individual contribution of each of the three factors—land, capital and labour—to production on farms there is no difficulty in ascertaining their total combined contribution ; and as there is no way of measuring individual contribution to the result there is no precise method of determining what ought to be the proportion of the result received by each in distribution. This will be determined by various social forces and conditions, some of which arise within and some without the industry itself. But always the maximum of remuneration for the three factors is determined by the net output.

The only way in which the total immediate income or consumption of the three interests concerned can exceed the amount of the net output is by using a part or the whole of the original capital of one or more of the interests. The farmer who fails to make profits may live for some years on the proceeds of sales which represent deductions from his original capital, and even the farmer who suffers losses may live for some time on his capital. The owner of a farm may consume all his rent and thus reduce the productivity of his land and buildings by failing to execute repairs and generally replace the ordinary wear and tear of production. The workman also may live on his capital, though this fact is not sufficiently recognised. In the experience of nearly all generations of farm workers there has been a time in which, through low wages, the whole class lives for a time partly on its accumulated resources. Even when the whole class is not suffering, there are times in which a part of the class is forced by lack of employment to live on its resources, and thus the total resources of the class are diminished. When conditions improve the unemployed are reinstated in the industry, and so must be regarded as part of its normal human equipment. Consequently. any diminution of their physical, mental or moral capacities, and that of any of their material resources which contribute to these, must be regarded as a diminution of the capital or of the resources of agriculture as a productive organisation.

To make allowance for the ordinary wear and tear of capital, in whatever form it may be used in production, a distinction has been made between "net output" and "net returns." As already stated, the net output is the sum which represents the contribution of land and improvements, of capital and the services of direction generally connected with it, and of labour to production; and it is the sum of value which remains after the cost of raw materials has been deducted from the total proceeds of production. To be strictly accurate, the deduction from total output should include an amount for estimated wear and tear of capital, whether in fertility, improvements on the land, or in other forms. It would then include the cost of raw materials used and the cost of the capital used up in current production. But as the repairs or replacements of wear and tear of capital are not necessarily done in the year in which the wear and tear occurs the net output may be ascertained without allowing for this. Consequently, it has been said that the workers' share of the net output is net income, from which no deductions have to be made; but the rent received by the owner is not net income, because allowance has to be made for repairs and upkeep of land and improvements. Thus, if the cost of maintenance of the farm over a period of years is 25 per cent. of the annual rent received the net return to the owner is only 75 per cent. of the rent. In the case of the farmer's capital, an allowance for the estimated amount of wear and tear and depreciation of capital can be made and added to the cost of the raw materials. If this is done the share of the net output received by the farmer

is net income. It may be said that a part of this is represented by interest due on capital and part by earnings due to the farmer's own services, but this is a question of distribution and not of production. If allowance is made for the actual wear and tear and depreciation of the farmer's capital in the current year of production, before the net output is ascertained, the question of the allocation of the farmer's share between capital and services does not affect the net output. In the treatment of net output of the farms below allowance has been made for depreciation of farmer's capital, but not for that of the landowner.

To make the matter quite clear, it has been stated that "net return" represents the total of the sum received by workers as wages, the rent received by the owner of land less the amount required to meet the cost of maintenance of the farm in productive efficiency, and the sum received by the farmer less the amount which is required for replacement of wear and tear of capital. Thus the net return is the total sum which is available for the personal as distinct from the business uses of the whole group.

In strict terms, however, this total is the real net output, for the net output cannot be ascertained until any wear and tear of capital, as well as cost of raw materials, has been deducted from the gross output or sales. Moreover, if it is true that at times the group of farm workers live partly on their accumulated resources, it is true that wages, like rent received, do not represent a sum which can be used wholly for personal as distinct from business purposes, although normally they are almost wholly used for personal purposes.

In addition to the raw materials purchased from outside the group, and to the services or materials supplied by landowners, farmers and workmen, the group requires other services to enable them to continue production. In particular they need road transport facilities and protection from possible enemies in human and other forms. These services are supplied by public authorities, mainly local in character, and are paid for by the rates levied by them. The whole of the services rendered to the group of agriculturists by the local authorities are not of a business character, for some are purely personal. But as it is common practice to admit local rates in estimates of costs of production they may be so treated for the purpose of ascertaining the net output. National taxes, on the other hand, are regarded not as payments for business assistance and services, but as payments for personal services, and in accounting they are generally regarded as deductions from profits rather than as costs. No clear line can be drawn between national taxes and local rates, for some part of the taxes levied for the national exchequer are expended on business services, while some part of rates levied for the local authorities are expended on such purely personal services as education. Some national taxes (such as those on automobiles) levied upon business requisities are, and should be, included in costs when the articles upon which they are levied are used for

business rather than for personal purposes. But on the whole, a fair separation is made when local rates are debited against costs, and national taxes are debited against profits, although both are expended partly on business and partly on personal services.

The alternative to this procedure is to regard the public authorities, especially the local authorities, as partners in the industry. The group of producers would then include landowners, farmers, workers and the public authorities concerned; and instead of debiting rates to the cost of products, they would be regarded as a charge against the net output. The alternative, in one actual instance, is as follows:—

EXAMPLE I.

PUBLIC AUTHORITIES AS PARTNERS.

Per Acre.

Gross sales		£20	19	10
Costs of raw materials		12	10	0
Net output		£8	9	10

Distribution.

Rent	£1	5	0	
Wages	3	6	6	
Profit	3	16	5	
Rates	0	1	11	
				£8 9 10

EXAMPLE II.

RATES AS COSTS.

Per Acre.

Gross sales		£20	19	10
Costs of raw materials	£12 10 0			
Services (rates)	0 1 11			
Net output		8	7	11

Distribution.

Rent	£1	5	0	
Wages	3	6	6	
Profits	3	16	5	
				£8 7 11

In Example I. the public authorities are regarded as partners in the industry, sharing the net result of the application of combined services in production, while in Example II. the services rendered by the public authorities, for which rates are paid, are regarded as necessary to production as are raw materials. But as they cannot actually be regarded as partners it is better to treat the public authorities as rendering services to production which have to be paid for without references to the results, or, in other words, treated in the same way as those persons outside the industry who supply raw materials. Moreover, if the rates paid by farmers are regarded as a share of the net output rather than as costs, then the rates paid by landowners and by workers on their cottages should be treated in the same way. The rates paid by the other partners in the industry are used for the same purposes as those levied on farmers, and if the public authorities are to be regarded as partners in the industry, and the rates they levy as their share of the net output, the whole of the rates paid by the agricultural group should be stated as one sum.

It has recently become possible to ascertain the net output per unit of each factor—of land, labour and capital—on certain groups of Scottish farms, and most interesting results are obtainable. In his report to the Board of Agriculture for Scotland on the *Financial Results of Sixty-Five Farms*,[1] Mr James Wyllie

[1] H.M. Stationery Office, 1922.

provides tabular statements of financial results on fifty-six farms, which are divided into eleven groups. These farms were situated in twenty-three counties of Scotland, and seem to have included most of the general types of farming in these counties.[1]

The accounts covered the period of one year, being closed either at Martinmas 1920 or at Whitsuntide 1921. The types of farming and average sizes of holdings in each of the sub-groups as given by Mr Wyllie, are as follows :—

TABLE I.

CLASSIFICATION OF FARMS.

Class.	System of Farming.	No. of Farms.	Average Size.
			Acres.
I. (*a*) Martinmas .	Dairying—Milk-selling . . .	2	206
(*b*) Martinmas .	Dairying—Cheese-making . .	3	329
(*c*) Whitsuntide	Dairying—Milk-selling . . .	7	198
		12	232
II. Martinmas .	Mixed—Dairy, Cropping, Feeding, etc.	4	326
Whitsuntide .	„ „ „ „ „	3	285
		7	308
III. (*a*) Martinmas .	Mixed—Cropping, Breeding, Feeding	12	371
(*b*) Martinmas .	Mixed—Cropping, Breeding, Feeding (Special)	2	291
(*c*) Martinmas .	Mixed—Cropping, Breeding, Feeding (Special)	4	52
(*d*) Whitsuntide	Mixed—Cropping, Breeding, Feeding (Small Holdings)	15	314
		33	301
IV. Martinmas .	Stock-rearing and Feeding . .	2	444
Whitsunside	„ „ . . .	2	462
		4	453
Total I. to IV.		56	298

Of these eleven groups of farms the farmers of nine groups, on the average, made profits while those of two groups suffered losses. It may be noted that of the two groups which suffered losses, one (I. (*b*) M.) is described as of a "dairying—cheese-making" type, while the other (II. W.) is described as of a "mixed—dairying, cropping, feeding" type. It is remarkable that the accounts for the first group which suffered losses were closed at Martinmas 1920, before the worst effect of the slump in prices had been felt. On this group of farms there was a depreciation in capital to the

[1] For list of counties, *see* Report, p. 17. Table I.
[2] *See* Report p. 17. Table I.

extent of £1, 13s. 3d. on the original capital of £23, 17s. 5d. per acre, but this depreciation is not alone sufficient to account for the loss of £2, 3s. 6d. per acre. For the other Group (II. W.), the accounts of which were closed at Whitsuntide 1921, the capital depreciation was 12s. 11d. per acre on the original capital of £22, 13s. 9d. per acre, while the loss was 11s. 9d. or slightly less than the capital depreciation. But other groups which enjoyed profits suffered greater capital depreciations. One group (I. (*a*) W.), of which the accounts were closed at Whitsuntide, suffered capital depreciation to the extent of 19s. 1d. per acre, while profits amounted to £1, 19s. 2d. The other Group (IV. M.) suffered capital depreciation of £1, 1s. per acre, while profits were £1, 14s. 7d. Accounts for this group were closed at Martinmas 1920. It is thus clear that capital depreciation does not wholly account for the greatest losses suffered by farmers (Group (*b*) M.); and even in the case of the smaller losses it is clear that the profits were affected by the efficiency of the organisation of the farms.

The following Table shows the net results of the organisation of production on eleven groups of farms for one year, with the distribution of the net result between the landowners, farmers, and workers and the public.

TABLE II.[1]

DISTRIBUTION OF NET RESULT (PER ACRE).

Group.	Net Output.	Labour.	Land.		Farmer.	
			Landowner Rent.	Public Rates.	Profit.	Loss.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
I. (*a*) M.	6 0 2	3 8 6	1 3 0	0 1 11	1 6 9	...
(*b*) M.	3 2 6	4 1 6	1 2 7	0 1 10	..	2 3 6
(*a*) W.	6 12 1	3 7 8	1 3 0	0 2 3	1 19 2	...
II. M.	13 5 5	4 7 0	1 17 4	0 2 8	6 18 5	...
W.	6 0 2	4 17 3	1 11 10	0 2 10	...	0 11 9
III. (*a*) M.	8 9 10	3 6 6	1 5 0	0 1 11	3 16 5	...
(*b*) M.	24 12 7	8 13 2	3 12 2	0 5 8	12 1 7	...
(*c*) M.	9 13 8	3 17 7	1 2 6	0 5 3	4 8 4	...
(*a*) W.	5 10 9	3 1 11	1 2 1	0 1 10	1 4 11	...
IV. M.	4 6 11	1 13 2	0 18 7	0 0 7	1 14 7	...
W.	5 2 3	1 19 6	0 13 6	0 1 2	2 8 1	...
Average	7 10 9	3 10 0	1 5 9	0 2 1	2 12 11	...

It is now necessary to indicate differences in the combination of the factors of production—land, labour and capital—on the various groups of farms in connection with their results. The following Table III. shows the gross income and total expenditure per acre of each group, and other tables analyse the expenditure

[1] *See* Report p. 26. Table XIII.

of the farmer between payments for raw materials and services, and payments to himself and his partners in production.

TABLE III.

TOTAL EXPENDITURE (PER ACRE).

Group.	Gross Income.	Minus Profit.	Plus Loss	Expenditure.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
I. (a) M.	13 17 3	1 6 9	...	12 10 6
(b) M.	16 14 1	...	2 3 6	18 17 7
(a) W.	15 15 7	1 19 2	...	13 16 5
II. M.	30 16 8	6 18 5	...	23 18 3
W.	17 8 1	...	0 11 9	17 19 10
III. (a) M.	20 19 10	3 16 5	...	17 3 5
(b) M.	55 15 1	12 1 7	...	43 13 6
(c) M.	23 5 7	4 8 4	...	18 17 3
(a) W.	19 4 3	1 4 11	...	17 19 4
IV. M.	10 6 2	1 14 7	...	8 11 7
W.	11 5 5	2 8 1	...	8 17 4
Average	20 1 5	2 12 11	...	17 8 6

Having ascertained the total expenditure of the farmers in each group, it remains to state the expenditure which is represented by purchasers of raw materials and by the amount of capital used up, so that the net output may be ascertained. This is given below.

TABLE IV.

GROSS OUTPUT, MATERIALS USED, AND NET OUTPUT (PER ACRE).

Group.	Gross Output.	Value of Raw Materials used and Capital used up.			Value of Net Output.[1]
		Raw Materials.	Capital = Decrease in Valuation.	Total.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
I. (a) M.	13 17 3	7 17 1	...	7 17 1	6 0 2
(b) M.	16 14 1	11 18 5	1 13 3	13 11 8	3 2 6
(a) W.	15 15 7	8 4 5	0 19 1	9 3 6	6 12 1
II. M.	30 16 8	17 11 3	...	17 11 3	13 5 5
W.	17 8 1	10 15 0	0 12 11	11 7 11	6 0 2
III. (a) M.	20 19 10	12 10 0	...	12 10 0	8 9 10
(b) M.	55 15 1	31 2 6	...	31 2 6	24 12 7
(c) M.	23 5 7	13 11 11	...	13 11 11	9 13 8
(a) W.	19 4 3	13 13 6	...	13 13 6	5 10 9
IV. M.	10 6 2	4 18 3	1 1 0	5 19 3	4 6 11
W.	11 5 5	6 3 2	...	6 3 2	5 2 3
Average	20 1 5	12 10 8	...	12 10 8	7 10 9

[1] Inclusive of rates, thus regarding Public Authorities as partners in the industry.

The reconciliation of the whole account in the cases in which loss was suffered by farmers is given below. As the landlord, the public authorities, and the workers were paid a total sum greater than the net output the farmer had to bear the loss.

		Group I. (b) *M.*		*Group II. W.*
Total Expenditure . .		£18 17 7		£17 19 10
Gross Income . . .		16 14 1		17 8 1
Loss borne by Farmer . .		£2 3 6		£0 11 9
Gross Income		£16 14 1		£17 8 1
Expenditure on Raw Materials and Decrease in Valuation .		13 11 8		11 7 11
Net Output		£3 2 5		£6 0 2
Paid as Rent .	£1 2 7		£1 11 10	
,, Rates .	0 1 10		0 2 10	
,, Wages .	4 1 6		4 17 3	
		£5 5 11		£6 11 11
Loss borne by Farmer . .		£2 3 6		£0 11 9

If the rates are taken as payments for services used in production, thus treated as expenditure on materials, the total expenditure on raw materials and services used and capital used up, and net output are as given below. If this is done, then public authorities do not take any share of the net output, and the result for the three partners in production remains the same.

TABLE V.

EXPENDITURE ON MATERIALS AND SERVICES (PER ACRE).

Group.	Gross Output.	Value of Raw Materials used and Capital used up.	Payment for Services as Rates.	Total Expenditure on Materials and Services.	Value of Net Output.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
I. (*a*) M. .	13 17 3	7 17 1	0 1 11	7 19 0	5 18 3
(*b*) M. .	16 14 1	13 11 8	0 1 10	13 13 6	3 0 7
(*a*) W. .	15 15 7	9 3 6	0 2 3	9 5 9	6 9 10
II. M. . .	30 16 8	17 11 3	0 2 8	17 13 11	13 2 9
W. . .	17 8 1	11 7 11	0 2 10	11 10 9	5 17 4
III. (*a*) M. .	20 19 10	12 10 0	0 1 11	12 11 11	8 7 11
(*b*) M. .	55 15 1	31 2 6	0 5 8	31 8 2	24 6 11
(*c*) M. .	23 5 7	13 11 11	0 5 3	13 17 2	19 8 5
(*a*) W. .	19 4 3	13 13 6	0 1 10	13 15 4	5 8 11
IV. M. . .	10 6 2	5 19 3	0 0 7	5 19 10	4 6 4
W. . .	11 5 5	6 3 2	0 1 2	6 4 4	5 1 1
Average . .	20 1 5	12 10 8	0 2 1	12 12 9	7 8 8

The last column in the above Table V. shows the value of the net output per acre, and it now remains to show, for each

group the amounts of land, labour and capital required to produce those results. Unfortunately, Mr Wyllie has not provided any record of the actual number of persons employed on the farms, as all labour statements are given in terms of "standard men," a "standard man" representing payments in wages to the amount of £135 per annum. This method of treatment makes it impossible to arrive at any judgment of the comparative efficiency of actual groups of men, although it does show the comparative efficiency of the amounts of labour procured for £135. The combined statements of labour in actual terms of persons, with indication of sex and age, and in terms of the cost of the labour, makes possible a comparison, for any groups of farms, of the productive efficiency of labour, but for the present only the estimate of labour in terms of the "standard man" can be used.

Another item of great importance in ascertaining the quantity of the factors required for producing a given amount of net output is the treatment of the land as a productive element. Land not only varies in fertility, but the improvements and buildings on the land also vary in usefulness for production. Consequently, a unit of land and equipment (as an acre or 100 acres) may vary enormously in productivity. In the cases under consideration such variations are indicated by the fact that the rents vary from £3, 12s. 2d. to 13s. 6d. per acre. It does not follow that the variations in fertility of land are as great as the variations in the rents, but the variations in productivity (*i.e.*, the variations in value-producing capacity due to the combined variations in soil and climate, farm equipment, and situation as regards markets) are probably greater than those in the rents. As competition is usually keener for the lower rented farms, because of the greater number of farmers having the necessary capital to cultivate them, the rents of these farms are generally nearer to their full annual value than those of the more highly rented. In the cases under review, it is noteworthy that the highest profits coincide with the highest rents.

As the productivity of a unit of land or, more accurately, land and permanent equipment varies to such an extent it is necessary to find a common equivalent. This may be found in capital values, which in the following Tables have been estimated at twenty years purchase on the rental. An actual valuation of the farms would be preferred, but as this is not available some estimate of capital values must be made. It may be thought that a flat-rate of capitalisation of twenty years' purchase will not give accurate or fair representation of capital values, but the effect of a varying number of years purchase on the total results may easily be calculated. The most important point at the moment is the indication of the unreliability of the mere unit of land as a measure of productivity. On the farmers' capital nothing need be said, for the values given are based on valuations. It is, however, necessary to state that the mere possession and use of capital on a farm does not give the owner a right to interest or profits, much less to

interest or profits at given rates; for this right depends upon the usefulness and productivity of the capital invested. The proper investment of available capital, and the organisation of its use, together with the organisation of the use of the land and the labour, is the measure of the farmer's efficiency. It is, therefore, important to measure the differing degrees of productivity of the farmers' capital.

The table below shows the rent, value of land, farmers' capital and number of "standard men" employed and net output, per 100 acres of land in each of the groups of farms.

TABLE VI.

RENT, VALUE OF LAND, FARMERS' CAPITAL, "STANDARD MEN" AND NET OUTPUT PER 100 ACRES.

Group.	Rent.	Value of Land.	Farmers' Capital.	"Standard Men."	Net Output.
	£	£	£	Number.	£
I. (*a*) M.	115·00	2,300	1651·25	2·54	591·25
(*b*) M.	112·91	2,258	2387·08	3·02	302·91
(*a*) W.	115·00	2,300	2055·83	2·50	649·16
II. M.	186·66	3,733	2612·08	3·22	1313·75
W.	159·16	3,183	2268·75	3·60	586·66
III. (*a*) M.	125·00	2,500	2038·32	2·46	839·57
(*b*) M.	360·83	7,216	4658·75	6·41	2434·57
(*c*) M.	112·50	2,250	3255·83	2·89	1942·08
(*a*) W.	110·41	2,208	1765·00	2·29	544·57
IV. M.	92·91	1,858	1617·50	1·23	431·66
W.	67·50	1,350	1406·25	1·46	505·41
Average	128·75	2,575	2079·57	2·59	743·32

This table shows quite clearly the variations in net output per 100 acres of land, and indicates to some extent the variations in the organisation of production with regard to the relative amounts of capital and labour employed. But it does not indicate at all clearly the yield per unit of capital or labour. This may be shown as in the following Table where the amounts of net output per £1000 value of landowner's and farmer's capital, and that per "standard man" are given.

It is now possible to judge the productivity of the various groups of farms on the unit of any one of the factors in production. And, if it were necessary for society to procure the greatest economy in the use of any one factor, this Table would provide a guide to the most productive system. Thus, if land were the most important factor, Group III. (*b*) M. gives the best, and Group I. (*b*) M. the worst result. But when mere surface area is not regarded as the unit of the land factor, and capital values of land and buildings are taken into consideration, Group III. (*c*) M. gives the best results, while the worst result is as before. Group III. (*c*)

M. gives the best result as regards both farmer's capital and per man, while Group I. (*b*) M. gives the worst results. Altogether it is clear that Group III. (*c*) M. gives the best and Group I. (*b*) M.

TABLE VII.

VARIATIONS IN NET OUTPUT PER UNIT.

Group	£1000 of Landowner's Capital.	£1000 of Farmer's Capital.	Per Standard Man.	Per 100 Acres Land.
	£	£	£	£
I. (*a*) M.	214	358	232·7	591
(*b*) M.	134	127	100·3	303
(*a*) W.	282	316	259·6	649
II. M.	352	503	408·0	1314
W.	184	258	162·9	587
III. (*a*) M.	336	412	341·3	840
(*b*) M.	337	522	379·8	2435
(*c*) M.	863	596	672·0	1942
(*a*) W.	246	309	237·8	544
IV. M.	232	267	350·8	432
W.	374	359	346·1	505
Average	288	357	287·0	743

the worst general results, but it is not easy to place the other groups. It is noteworthy that although the worst group as shown by this Table is that in which farmers suffered the greatest loss the best group is not that in which farmers received the greatest profit.

As society can never judge the value of a system of farming by the yield of output per unit of one factor in production, because all are necessary, it is desirable that a measurement of the production of the combined factors shall be obtained. Such a measurement is doubly valuable in that it indicates the productive efficiency of the combinations of different amounts of owner's capital, farmer's capital and labour. This measurement is indicated in the following Table, where the amounts of the factors of production required per £1000 value of net output on each group of farms are shown.

The average amount of owner's capital required to produce £1000 value of net output is £3468, the highest being £7454 and the lowest £1158. In the case of the farmer's capital the average amount required was £2797, the highest and lowest being respectively £7880 and £1676. The average number of "standard men" was 3·48 per £1000 value of net output, but in one case 9·97 were required and in another only 1·49 men were required. But if the contents of this Table are stated in their mere numerical quantity, taking the average requirements as the standard, it becomes possible to state definitely which is the most and which is the least efficient group and to indicate the order of efficiency for the

whole of the groups. In this connection it must be remembered that taking the average as the standard requirements diminishes differences, for if the best group were taken as the standard

TABLE VIII.

LANDOWNERS' AND FARMERS' CAPITAL AND STANDARD MEN REQUIRED PER £1000 VALUE OF NET OUTPUT.

Group.	Landowners' Capital (Value of Land).	Farmers' Capital.	"Standard Men."	Value of Net Output.
	£	£	Number.	£
I. (*a*) M. . . .	3890·06	2792·81	4·29	1000
(*b*) M. . . .	7454·	7880·	9·97	1000
(*a*) W. . , .	3543·04	3166·90	3·85	1000
II. M. . . .	2841·48	1988·26	2·45	1000
W. . . .	5425·63	3867·23	6·13	1000
III. (*a*) M. . . .	2977·71	2427·81	2·93	1000
(*b*) M. . . .	2963·97	1913·58	2·63	1000
(*c*) M. . . .	1158·65	1676·48	1·49	1000
(*a*) W. . . .	4054·57	3241·27	4·20	1000
IV. M. . . .	4304·31	3747·16	2·85	1000
W. . . .	2671·09	2782·39	2·89	1000
Average . . .	3464·18	2797·67	3·48	1000

differences would be much greater. The average is, however, the fairer standard, for no objection can be urged against the comparison of the efficiency of any group with that of the average of all groups, especially as the whole contains groups in which the farmers suffered losses as well as those in which they received profits. It is possible that the results in the best groups were to some extent due to temporary circumstances, but this could not be true of the whole of the groups. Therefore, the requirements of owner's capital, farmer's capital and labour per £1000 value of net output are taken for the whole group of fifty-six farms, and comparison is made for individual groups, with results as below.

The results for the second and fifth groups of farms (I. (*b*) M. and II. W.) are interesting because these were the groups in which farmers suffered losses. All other groups are fairly comparable because they all yielded more or less profit. But the bad organisation of the second group is evident in the fact that, even if no loss had been suffered, the amount of the factors required for £1000 value of net output would have been 4·55 as against 3·00 for the average of all groups, 1·36 for the best group and 3·39 for the worst of the groups which succeeded in yielding a profit. Even in the case of the fifth group (II. W.) where the loss was only 11s. 9d. per acre, the amount of the factors required to produce £1000 value of net output, if no loss had been suffered, would have been 3·98 as against 3·00 for the average and 3·39 for

the worst of the groups which succeeded in making a profit. On the whole it appears that both these groups of farms suffered from bad organisation and management, for production was by no

TABLE IX.

COMPARISON OF AMOUNT OF FACTORS REQUIRED TO PRODUCE £1000 VALUE OF NET OUTPUT.

Group.	Landowners' Capital (Value of Land).	Farmers' Capital.	"Standard Men."	Total.
	£	£	£	£
Average . . .	1·00	1·00	1·00	3·00
Group—				
I. (*a*) M. . .	1·12	0·99	1·23	3·34
(*b*) M. . .	2·15	2·81	2·86	7·82
(*a*) W. . .	1·02	1·13	1·10	3·25
II. M. . . .	0·82	0·71	0·71	2·24
W. . . .	1·56	1·38	1·76	4·70
III. (*a*) M. . .	0·86	0·86	0·84	2·56
(*b*) M. . .	0·85	0·68	0·75	2·28
(*c*) M. . .	0·33	0·60	0·43	1·36
(*a*) W. . .	1·17	1·16	1·20	3·53
I. M. . . .	1·24	1·33	0·82	3·39
W. . . .	0·77	0·99	0·83	2·59

means as heavy as the amounts of capital and labour employed would warrant and indeed require.

But the strangest result of all is that the first place in efficiency must be given to the group of small farms, averaging 52 acres each (Group III. (*c*) M). It is possible that the result in this case is due partly to the conversion of labour into "standard men" on the basis of wages, for it is probable that the small farmers and their families would work harder or more continuously than the hired workers of other groups. But, allowing for this, the factors of production are remarkably well balanced and the results show high efficiency in organisation and in the use of both capital and labour.

The results for other groups are well worth some study, both in arithmetical form and on the farms themselves. It will be noticed that in the cases in which the quantities of the factors used are below the average the quantities of each of the factors are, on the whole, well balanced. This is the case with Groups II. M., III. (*a*) M., and III. (*b*) M.; which were also the groups showing the highest profits. As regards other groups, it is practically certain that the farmers in I. (*a*) M. are under-capitalised for the type of business they are carrying on, while the farmers in IV. W. are over-capitalised for their type of farming; and in the case of IV. M. it is quite certain that insufficient labour was employed to obtain the best results.

To summarise results, the order of merit of the organisation of the different groups may be given as for the different standards of judgment which may be applied. These are :—

The gross output per acre of land, which implies the fullest use of the land itself.

The net output per man, which implies the best possible use of labour, and the highest possible (average) standard of living for those engaged.

The gross return on farmer's capital, which implies the highest profit return per unit of farmer's capital.

The gross wages paid, which implies the greatest employment of labour per unit of land.

The "efficiency factor" which implies the most economical use of land, labour and capital in production.

The last is measured by the amounts of land, capital and labour required for an equal amount of net output from each of the groups.

TABLE X.

ORDER OF MERIT.

Group.	Gross Output per Acre.	Net Output per Man.	Gross Returns on Farmers' Capital.	Wages per Acre.	Efficiency Factor.'
I. (a) M. . .	9	9	8	6	7
(b) M. . .	7	11	11	4	11
(a) W. . .	8	7	7	7	6
II. M. . .	2	2	1	3	2
W. . .	6	10	10	2	10
III. (a) M. . .	4	6	3	8	4
(b) M. . .	1	3	2	1	3
(c) M. . .	3	1	5	5	1
(a) W. . .	5	8	9	9	9
IV. M. . .	11	4	6	11	8
W. . .	10	5	4	10	5

It is amongst these conflicting standards that judgment must be made. The person who is solely concerned with the supply of food may judge by the gross output per acre. The whole group of agriculturists actually engaged in production may judge by the standard of net output per man, which sets the limit to the average standard of living for the group. The farmer may judge solely by the profit return on his capital which he may take for his own use. The person who is concerned with the health and physique of the race, or with unemployment of labour, may be inclined to judge by the amount of labour employed without reference to the possible standard of living or the return on capital. But the only standard of production which is at once comprehensive and generally useful is the amount of net output per unit of the combined factors of production.

COMMERCIAL HORTICULTURE IN SCOTLAND.

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THE most important sections of commercial horticulture found in Scotland are fruit growing, vegetable growing and tomato growing. Tomatoes are only grown under glass and do not come within the scope of this article.

FRUIT GROWING.

There is a certain amount of land devoted to fruit growing in almost every county in Scotland, but the counties where orchard and small-fruit are grown commercially are limited to Lanark, Perth, Midlothian, Fife, Haddington and Aberdeen, and of these by far the most important areas are in Lanark, Perth and Fife. Only in Lanarkshire and Perthshire are found large-fruit holdings.

Lanarkshire.—While the area under fruit in Lanarkshire is probably less than that in Perthshire, the county still remains the chief fruit-producing county of Scotland. This is due in part at least to the very diversified nature of the fruits grown. Here may be found in greater or less quantity, apples, pears, plums, cherries, gooseberries, red and black currants, raspberries and strawberries. The area under strawberries is at least as great as that under all other fruit crops combined.

Lanarkshire has been a fruit-growing county for many centuries. "It was noted as such in the fifth century by Merlin, the poet, who celebrated Clydesdale for its fruit, and in the eighth century the 'apple-yards of Lanark' find reference in the writings of the Venerable Bede (674–735). No very complete or comprehensive account of the origin or development of the fruit industry in this county seems to be in existence. John Naismith in his *General View of the Agriculture of the County of Clydesdale* (Macmillan, 1806) gives a short description of the orchards in this county, and the following particulars are taken from that source. In 1794 there were 200 acres under fruit, and in 1806 there were 340 acres. The value of the fruit crop in 1801 and also in 1802 was £5000, but in some years the fruit realised only £2000. Apples were the chief crop, pears being grown to a less extent, whilst cherries were rarely planted." [1]

The section where most of the fruit is grown is along the lower reaches of the Clyde and extends from Lanark to Uddingston. Very little extension of the area under large fruit has taken place during the last half century; in fact some of the most famous of the old orchards are now little more than names, but the area under bush fruits has greatly increased. Most of the orchards in this district are also used for crops of gooseberries or strawberries

[1] "The Fruit-Growing Industry in Lanarkshire," by A. Hosking, *The Scottish Journal of Agriculture*, Vol. i., No 4, October 1918.

(sometimes for both) or to a limited extent for red currants and black currants. The land is usually kept under tillage and it is the exception to find an orchard in permanent grass.

The large fruits most commonly grown are apples and plums and the Clyde Valley is justly famous for its very fine Victoria plums. Pears are grown only to a limited extent as they do not do so well as the other fruits. Most of the pear orchards are very old and contain inferior varieties, and they are often scarcely worth the picking. Most of the fruit is marketed directly in Glasgow.

The following table is based on the Returns of the Board of Agriculture for Scotland for the year 1915 (Cd. 8501):—

Kind of Fruit.	Area in Scotland.	Lanarkshire. Area.	Average Yield.	Average Price per Ton.	Total Value.
	Acres.	Acres.	Per acre.	£	£
Apples	517	77	2½ tons.	10	1,925
Pears	724	71	2½ "	20	3,550
Plums	139	64	2 "	15	1,920
Cherries	75	42	3 "	15	1,890
Mixed areas, chiefly large fruit	533	276	3½ "	20	19,320
Strawberries	2,718	1,293	2 "	20	51,720
Raspberries	2,678	71	1½ "	25	2,662
Currants and Gooseberries	1,196	502	3 "	15	22,590
Mixed areas, chiefly soft fruit	462	120	3½ "	15	6,300
Totals	8,542	2,516	...	...	111,877

Note.—In this table fractions less than ½ of an acre are not taken into account.

Perthshire.—In Perthshire there are several very important orchards, but there is not the same proportion under plums, apples being the chief crop. Many of the orchards are under permanent grass and it is a usual practice to auction the fruit *on the trees.*

Strawberry Growing.—In Scotland there are about 2,500 acres devoted to this crop, and of these by far the greatest part is in Lanarkshire where the strawberry as a field crop was introduced within living memory. It has made rapid strides and the crop is now grown successfully on soils which vary very much in character, and in situations which differ very markedly in aspect.

Satisfactory crops are grown on soils which vary from the light sands to very heavy clays, and in diverse aspects which slope towards all the points of the compass. There is also very great variation in the altitude in which strawberries are grown and consequently in the time of ripening of the fruit. So great is this difference, that strawberries in the lower reaches of the Clyde are often marketable before even the earlier kinds are in bloom in the more elevated regions.

The methods adopted in this area differ considerably from

those in vogue in England, both as to the preparation of the soil and the time and method of planting. In Lanarkshire the bed system is almost the only method found and this makes it impossible to apply dung after the crop is planted, and also precludes the possibility of horse cultivation. Hand-weeding is comparatively expensive and makes the costs of production considerably higher than in the south. Autumn planting, so usual in England, is rarely adopted as the long continued, cold, wet winter causes great mortality among the plants and in any case there is not usually a supply of runners available at that season. The yield per acre is considerably less than was the case in the days when "The Countess" and other old varieties were in favour, but the value of the crop has also advanced greatly from what it was in the nineties.

The strawberry is a crop which might be capable of considerable expansion. Many districts which at present have to depend on fruit sent from the larger markets should prove suitable for the growing of strawberries to a limited extent without seriously affecting the price of this commodity, and consequently without lessening the return to the grower. The strawberry is, however, a relatively expensive crop to grow and much of the success of the crop depends on weeding and it is usually necessary to train the labour for the work. Much more labour is necessary than for agricultural crops and this labour should be available from April until September. It is essential, therefore, that the intended area be within easy reach from the centres of population.

Much of the labour employed in the Clyde Valley is women labour, and the fruit is either marketed in chips or sold direct to the preservers.

Raspberry Growing.—Here again we have localisation of an industry. Most of the raspberry farms are in Perthshire, and so rapid has been the development of this crop that this county has now the greatest acreage under fruit in Scotland. Raspberry growing, however, is not restricted to Perthshire as a fairly large quantity is grown both in Fifeshire and in Forfarshire.

The Blairgowrie method differs considerably from that found in many of the English raspberry districts, in that the former is the single-row espalier system while in the south the broad-mounded row is favoured. The Scottish system is certainly the more easily managed and presents a much neater appearance, but the English system probably lasts longer and is not so expensive to start with.

The development of the fruit industry in Lanarkshire and in Perthshire presents another illustration of the peculiarity that has time after time been observed in connection with intensive cropping, viz., that rarely do the regular agricultural workers embark on such an enterprise. It is indeed very seldom that one finds a farmer or farm labourer becoming a fruit grower. Whether this is a question of the different mental outlook of the average agriculturist, or whether it is due to lack of business training, it is difficult to say, but fruit growing embraces people from all other arts and crafts.

In the old days many small farmers grew and marketed a small quantity of fruit; but there was usually a direct relation between the producer and the consumer. This is, however, a thing of the past as is also the old custom of selling out an orchard to the highest bidder. The grower has now to produce for the retail trade and to supply those articles which the wholesaler can most readily dispose of. Supplies of definite quantities of goods of a specified quality are usually essential, and careful grading and packing is a very important factor. The business man is usually more able to cope with this part of the business than is the farm worker.

In any intensive cultivation of the land, personal supervision of all branches of the business must always be a dominant factor, and the more highly specialised the crop produced, the more essential does it become that the grower should be able to overlook completely all the work on the holding or else have the personal labour of other members of his family.

In a cursory survey, all the fruit districts show the same evils to a greater or lesser extent, evils which are usually attendant upon specialisation in any particular crop. Most of the holdings where strawberries and raspberries are grown in the aforementioned districts are too small to allow of proper and systematic rotations, and this involves the continued use of the ground for a particular crop for too long a period at a stretch.

Where the total area is under ten acres, the method of having other crops occupying the land during half the rotation cannot be adopted, and various troubles due to insect pests and fungus diseases, which under proper cultural conditions might be almost negligible, become accentuated and cause grave loss. The method, all too common, of planting up fields which are badly infested with raspberry weevil, with the same or with some other fruit crop after only one year's cultivation is bad, and can only lead to serious disappointment. In several of the raspberry districts it is evident that some other crop should be substituted for this fruit, and reversion to ordinary agricultural cropping would be beneficial, if it is not actually imperative. There are other districts in which the crop would be eminently successful, but the greatest difficulty is the immobility of the permanent equipment.

The crops in the older raspberry districts have shrunk from 3–4 tons to 25–35 cwts. per acre, and the yield in those districts which are more nearly exhausted would average about 15–20 cwts. per acre. Certain new districts report crops of 2½–3 tons per acre, so that some account must be taken of the retarding effect of impoverished land since the difference in yield cannot reasonably be attributed to exhausted varieties.

Intending fruit growers should first investigate the market possibilities, then make enquiries concerning the labour supply before embarking on this occupation.

Farm Orchards.—Taken as a whole there are very few farm orchards in Scotland, whereas in England the farm orchard is quite common, and from recent surveys carried out in Ontario it is

seen that even on the mixed farms the area under orchards averages about 3 per cent., while it is as high as 5 per cent. on the dairy farms.

Many farmers do not grow even sufficient apples for their own use. Certainly there are numerous farms in Scotland where apples could not be expected to grow at all, and others in which only the hardier varieties of cooking apples would succeed, but there are, nevertheless, hundreds of farms on which a small orchard suitable for the needs of the household might be profitably established.

Where farm orchards do exist, they usually leave much to be desired, both as to the varieties grown and as to the condition of the trees. Various insect pests and fungus diseases are common and the trees are usually seriously affected by a luxuriant growth of moss and lichen. Many of the trees are so old that they are of little value, producing only spasmodic crops of poor scrubly fruit. Little attention is paid to the questions of spraying, pruning and manuring.

The question of the farm orchard is a different one from that of the grower's orchard, since that on the farm has usually to serve the two-fold object of producing fruit and of affording shelter for stock, as for example ewes during lambing time. For this reason such orchards will usually be laid down in grass, although fruit trees most certainly do best when the land is cultivated round them during the early stage.

Much might be done towards renovating such orchards by rigorously removing all dead or diseased wood, and by a judicious removal of the older wood to encourage new growths from lower down the branches. Judicious heading-back may be practised with advantage, especially where the trees interlock, but the object of this is not to obtain a large stock of wood for the fire.

In some cases it would be advantageous to remove completely the smaller or decrepit trees which interfere with their more robust neighbours. Where the trees are lacking in vigour or are of inferior or unsuitable varieties, it is often necessary to crown graft with more suitable kinds.

Much benefit will be derived from the removal of the moss and lichen, and this may be most easily done by spraying the trees with one of the following washes:—

1. Hot lime wash made from a good quality lime used at the rate of 1 lb. freshly burnt lime to a gallon of water.
2. 2 lbs. caustic soda 98 per cent.; 5 pints petroleum; 10 gallons water.
3. Commercial concentrated lime-sulphur diluted with nine times its volume of water.

The wash selected should be applied during the winter, using considerable force, and might be followed beneficially by an application of copper sulphate solution (1 lb. to 25 gallons of water).

The orchard will probably need manuring, and where it is allowed to grow in grass this should be mowed more than once during the season to form a mulch, and a light coating of farmyard

manure given during the winter. Artificials may also be required and these should consist preferably of readily available nitrogenous, phosphatic and potassic manures in the proportion of 1 : 2 : 1 applied at the rate of 2 to 3 cwts. per acre all over the orchard. Nitrate of soda or sulphate of ammonia may be used to supply the nitrogen; superphosphate is the best source of the phosphate, though this should not be mixed with nitrate of soda; and muriate or sulphate of potash should be used as the potash manure.

Before planting a farm orchard, it would be wise for the farmer to get local information as to what varieties do best in the district and also to obtain some modern information as to stocks most suitable for his purpose. In all newly-planted orchards the ground for a radius of 2 to 3 feet round the trees should be kept cultivated, and this is especially important up to the tenth year.

Market Gardening.

Land in the immediate vicinity of the larger industrial areas is often devoted to market gardening, but with the exception of the Lothians there are no large market garden areas in Scotland such as one finds further south. The market gardens in Midlothian are justly famous throughout the British Isles.

Owing to the bulky nature of the crops grown and their generally perishable character, nearness to station or to market is an important consideration. With the rapid development of motor transport the distance that can be accounted near to a market has, however, greatly increased, for whereas ten miles from market would be a long distance for horse transport, twenty miles would be within easy reach with motor transport.

In contemplating the possibility of starting market gardening, the following points should be observed:—

1. Market garden crops are usually so perishable that ability to market the crops to advantage is quite as important as ability to grow. There is often considerable discrepancy between the prices obtained by two growers for similar consignments at approximately the same time.
2. There must be an ample supply of reliable labour. Since the advent of the motor lorry it has been possible to transport labour more easily than was previously the case, but this is often an expensive undertaking.
3. Abundant supplies of good stable manure must be obtainable and the haulage of this material from a great distance is economically unsound. For this reason nearness to a station or siding is imperative.
4. Quickness of despatch and uniformity of quality, thereby earning a reputation for reliability, are important assets.
5. Skill in determining what crops are the most profitable is very important, and some system of accounting is desirable.
6. Certain crops may be relatively unprofitable during a short period, but sooner or later they usually reward the grower for his perseverance.

Some market garden crops make very high prices during certain years and appear, therefore, to be particularly profitable. As an instance of this one may mention mushrooms. Many farmers with substantially built outhouses might easily grow this crop provided they could obtain ample supplies of fresh horse manure, but there is only a very limited demand and the Scottish markets are easily glutted. Many other crops could, however, be grown without taking up the cultivation of these temptingly-priced articles which are, after all, the special province of the expert grower.

It is better to confine oneself to commodities which are in universal demand, and are also consumed in quantity. Rhubarb, cabbage, cauliflower, carrots, peas, turnips and beetroot may be instanced. The markets of Glasgow and Edinburgh are usually sufficiently well supplied with rhubarb and cabbage, but many of the smaller towns and the more scattered industrial areas are dependent on these markets for the bulk of their supplies, and, as a consequence, these vegetables are retailed in a much inferior condition to what might be the case if supplies were marketed direct. The local demand, especially for forced rhubarb, is, as a rule, very indifferently met by the home growers in these districts, and this should prove a very remunerative crop.

Onion growing, especially for spring and summer pulling, might be and is very profitable in many districts, though the profits which accrue are by no means constant, as this crop may scarcely pay its way in one season, while in another the returns may be so high as to more than compensate for the low level obtained in other years. A word of warning is necessary so far as this crop is concerned. On no account should land which is not in a high state of tilth and fertility or which is at all foul be sown with onions.

In considering the question of costs of production of most of the market garden crops, there is generally a difficulty, since, where the crop occurs simply as one in a definite rotation (as for preference it should), any heavy application of manures and fertilisers must be charged against all the crops in the rotation, and not against the particular crop in preparation for which or to which it is applied. The cost of production of a particular crop is an important factor, but the price received is of at least equal importance. For this reason it is important to aim at a very high grade article, as the difference in price between the best and the lowest grade will often be greater than the total cost of production.

THE SMALL HOLDER AS A FRUIT GROWER AND MARKET GARDENER.

Agriculture is not at present in a very flourishing condition, and the small holder who depends chiefly on agricultural crops and who makes his holding a miniature farm is bound to feel the full force of this depression. He is unable to make the same reduction in the costs of production as can the large farmer, and with his

very limited area the total value of his crops may not represent a satisfactory living.

If the small holding be run on purely agricultural lines, it is unlikely that the small holder will obtain the best returns for his labour. It is, therefore, desirable that the small holder should take up such specialised lines as fruit and vegetable growing, poultry-keeping, dairy-farming and pig-rearing. Pig-rearing and poultry-keeping can be very successfully combined with market gardening or fruit growing.

Before embarking on market gardening or fruit growing, the small holder should satisfy himself as to the following details:—

1. That he has sufficient business ability to market his goods to the best advantage. It is as important to have the marketing instinct as to possess the ability to grow. Business connections with reliable dealers must be built up, and close touch with the markets maintained wherever the crop is of a perishable nature.
2. The small holding must be situated within easy reach of a railway station, both for the economic transport of the necessary materials and the despatch of the produce.
3. The land should be easily worked and in good heart, and freedom from weeds is desirable.

Due enquiry should be made to ascertain if there is sufficient demand for the crop or crops contemplated, and also as to whether these crops have been tried in the district. The grower may be able as the time goes on to educate the district in the use of a particular vegetable or fruit, but this is not a remunerative process, and the beginner must be content to supply those goods for which there is already a known demand.

Suitability for market gardening will be further dependent upon the texture of the soil, and on the earliness of the district. Land which is of high natural fertility, but difficult to work and relatively late, will not be so suitable for market gardening as land which may have a low reserve of food material, but can be easily worked and will return in full measure in the crop whatever is put into the soil.

The climatic conditions play a very important part in determining the success of market gardening, Where the winter is long and cold, very little can be done except by the use of glass structures to ensure that the land is kept under crops during a prolonged period, and the success of market cropping is largely dependent upon the ability to obtain more than one crop from the land within the year. At least three crops in two years should be possible, and the intervals between the crops should only be sufficient to get the land into condition for the succeeding one. Properly cultivated market gardening land should always be ready for the reception of a crop so far as its tilth and cleanliness are concerned.

For fruit growing, situation is usually the deciding factor. Most of the fruit areas are found within the confines of the

valleys formed by rivers, and the natural warmth in such situations and the shelter afforded by the surrounding hills give them a decided advantage over other districts. Top fruit does not make headway in very exposed situations, and in the absence of natural shelter it is necessary to provide this. Gooseberries, raspberries and strawberries will do in more exposed situations and at higher altitudes than will top fruit. The plum zone is a very restricted one, from 100 to 350 feet above the sea level being the approximate limits. Apples will succeed up to 500 feet, and gooseberries and strawberries at much greater heights. Black currants flourish at comparatively high levels, provided other conditions are satisfactory, but they are somewhat exacting as to shelter and soil. The soil should be easily worked, of good depth and rich in organic matter, and while it is essential that the drainage be good, the water-holding capacity must be high.

Where an orchard is to be established it is customary to inter-crop large fruit with gooseberries or currants, and to plant strawberries at the ground level. This may be the quickest method of obtaining a return from the ground planted, but there is no doubt that both gooseberries and top fruit suffer from the competition with the strawberries. The small holder must, however, determine which method he will adopt.

MARKETING FRUIT AND VEGETABLES.

As has been stated already, the old personal connection between the producer and the consumer no longer obtains to any extent. Most of the produce is sent to the wholesaler, who sells on commission to the retailer, who, in turn, disposes of his wares to the consumer. Only in the smaller towns and with the small grower is the crop sold direct to the retailer. These intermediaries are an essential part of the commercial system, and where the service they render to the grower and to the community is performed for a just charge, no hardship can arise either to the producer or to the consumer. In many cases it happens, however, that the amount of competition amongst the wholesalers is artificially limited by the insufficient size of the markets, and that in this way a temporary monopoly is set up.

The wholesalers' charges vary from an inclusive one of 10 per cent., to a more fluctuating one which may be as high as 15 per cent. As examples of the incidence of market costs (exclusive of freight) on the net returns to the grower, the following typical Clyde Valley returns may be cited:—

Nature of Crop.	Return to Grower.			Total Selling Charges.			= Per Cent.
	£	S.	D.	£	S.	D.	
Apples and Pears	89	2	1	13	17	5	15·5
Raspberries and Strawberries . .	186	14	0	21	16	11	11·9
Mixed Consignments . . .	274	0	0	67	15	1	24·7

The following table showing comparison between 1913 and 1922 is instructive. The last line, "Per Cent. Cost," represents the proportion of the gross receipts paid by the grower for the various charges incident to the marketing of his produce exclusive of picking, packing, etc., the costs of which have not been included in the table.

	1913.				1922.			
	Plums.	Strawberries.	Strawberries.	Strawberries.	Plums.	Plums.	Strawberries.	Strawberries.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Total Return to Grower	19 2 11	29 7 11	6 4 11	6 17 0	16 9 2	19 1 0	63 13 6	4 2 0
Cartage to Station	0 6 0	0 6 0	0 4 0	0 4 0	0 8 0	1 0 0[1]	0 8 0	0 6 0
Carriage	0 12 0	0 12 0	0 3 4	0 4 2	0 18 5	...	1 2 6	0 8 7
Empties	1 10 0	1 12 6	0 10 0	0 12 0	3 0 0	0 18 0	3 0 0	0 1 9
Carriage on Empties	0 3 4	0 3 6	...	...	0 10 0	...	0 10 0	...
Receiving and Delivering	0 12 0	0 15 4	0 4 6	...	1 4 0	0 18 0	1 10 2	0 6 0
Commission	1 11 2	1 9 5	0 0 3	0 10 3[2]	1 4 9	1 8 6	4 15 7	0 6 2
Per Cent. Cost	24·7	16·7	22·4	22·2	44·7	16·9	17·7	34·6

[1] Delivered direct to market by motor lorry.
[2] Includes receiving and delivery.

When one adds to these charges the profits which the retailer takes, it is apparent that of the price paid by the consumer less than half (sometimes considerably less than one-third) finds its way into the pockets of the man who produces the crop.

Undoubtedly marketing costs and the amount taken for the selling of vegetables and fruit are high, and both the grower and consumer suffer thereby. Much might be done by the producers to remedy this, but, unfortunately, they are a body of individualists. While wholesalers and retailers have formed themselves into associations to protect their industry, the growers have made very little move in this direction. Co-operative effort in marketing, preserving and bottling fruit has proved successful in various parts of the world, and there is no reason why such a method should not be of equal advantage in Scotland.

"Co-operative marketing makes it possible to gather together the products of many small growers, and to consign these products to distant markets in full truck loads. The grading and packing are supervised by the organisation rather than by the individual producers. Thus a large volume of product packed in definite and uniform grades can be placed on the market."

"Under present market conditions a standardised product that can be offered in large volume sells much more readily and at better prices than miscellaneous lots packed according to various individual standards; and, furthermore, the standardised product is much more satisfactory to the consuming public."

"In a growers' co-operative marketing organisation each grower receives the full benefit of the advantages derived from large-scale operations and favourable trade connections made possible by the

organisation. The individual grower is protected against unusual losses due to low sales on any particular consignment; for in a co-operative marketing organisation each grower receives the same price for the same grade of goods consigned during a given period, regardless of whether the product he furnished happened to be in a truck that was consigned to an especially favourable or less favourable market, or whether some accident befell a given truck. A member of such an organisation is also protected from exploitation by unscrupulous dealers, and is sure of an outlet for his crop. He is not constrained to accept an offer for fear he will not receive another, or to consign his goods to an uncertain market as may become necessary when an individual is acting alone."

"Co-operative marketing has been successfully practised in both Europe and America for a number of years. The eggs, butter and bacon exported from Holland and Denmark have been handled very largely by co-operative organisations composed of the farmers who kept the hens, milked the cows and raised the pigs. These organisations made it possible for the owner of a dozen hens or one cow or one pig to market his product to as good advantage as if his output had been one hundred times as great." [1]

Railway charges and freights are still very high, and it is to be hoped that these will be reduced to an economic level.

TECHNICAL.

Modern commercial horticulture is becoming more and more dependent upon scientific research, and with the increasingly intensive nature of the cultivation and the higher specialisation of the industry, this dependence will of necessity be accentuated. There are numerous problems which require scientific investigation to enable the grower to successfully combat the troubles which effect his crops, and their number is constantly being increased. There is great need of experimental work on fruit to determine the stocks, varieties and treatment applicable to Scotland, and the raising of suitable varieties of strawberries and raspberries should be undertaken.

Research work on phyto-pathological and entomological lines is long overdue and urgently required, and Scotland is very far behind all other European countries in this respect. Fortunately for the Scottish grower, much of the very excellent work which has been carried out at the East Malling Research Station and at the Horticultural Research Station at Long Ashton is equally applicable to Scotland. Among the problems which are being actively pursued at these stations are:—

1. The resistance of root stocks to such diseases and pests as Crown Gall, Woolly Aphis and Silver Leaf.
2. Big Bud Mite and its control.
3. Reversion in black currants.
4. "Red Plant" in strawberries.
5. Canker control in apples.

[1] Amended from Circular, No. 238, University of Illinois.

In the study of these subjects very useful information has already been obtained. Hosts of other horticultural problems await solution, and there is no need to fear any undue duplication of the work. Collaboration would, in fact, be a decided advantage. These institutions have fairly large staffs, that at Long Ashton consisting of ten expert workers and several assistant workers, while at East Malling there are four full-time scientific workers and a number of associate research workers. The area available for this work at Long Ashton comprises about 217 acres, while at East Malling 62 acres are devoted to the purpose.

THE BIOLOGIST ON THE FARM.—No. XI.

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Changing the Egg Production of a Flock.—Man does not succeed in adding much to the list of animals which his pre-historic ancestors domesticated, but he certainly succeeds in improving what he has inherited. Take a recent story of the improvement of egg production in a flock of Rhode Island Reds. In 1912-1913 the average per bird annually was 114 eggs; in 1920-1921 it was 200 eggs. This represents an increase of seven dozen eggs per bird, resulting from the breeding methods followed. The pullets in the last flock recorded commenced laying at a much earlier age than those in the earlier flocks, there being a difference of 55 days in age at first egg between the first record and the last. The winter production of eggs per bird increased from 28 eggs in the earlier flocks to 67 eggs in the last flock.

How was it done? The method was to improve the flock by degrees, taking one desirable character at a time and making sure that it was well established in the flock as a whole before proceeding to concentrate selection on a second. The following suggestions for other keepers and breeders of poultry are offered by H. D. Goodale and Ruby Sanborn in Bulletin 211 (1922) of the Massachusetts Agricultural Experiment Station.

First Step.—Get the flock so that the pullets will mature before 200 days of age by choosing as breeders those that mature before that age. The males must be from hens of the same qualifications, or brothers to those families of pullets that give the greatest percentage of qualifying females.

Second Step.—Choose as breeders birds that mature right and are not broody. This step is not necessary for Leghorns.

Third Step.—As soon as a sufficient percentage of the flock—say 50 per cent.—qualifies in these two respects, make the breeders qualify in three characters. Require them to mature before 200 days of age: to be free from broodiness; and to lay 22 eggs in either November or December.

Fourth Step.—Add to the three points a fourth, that the hens shall lay not fewer than 80 eggs during the winter. Eliminate the winter pause and secure continuous production. Any pairing that gives superior results should be repeated, but females should not be used twice, at least with the same male, unless some of their progeny make an advance over the parent, or unless the family as a whole is better than the average of the preceding generation. All this is, of course, in accordance with nature's age-long process of sifting.

The Tracking Instinct in an Ant.—If we ever begin to suspect that the sense of wonder is becoming dull within us we have only to go out and look at ants. The more we know about them the more wonderful they become, partly, perhaps, because they are built on very different lines from ourselves. They have many instincts and not a great equipment of intelligence; we have few instincts but we are very quick to learn.

Take one of the recent stories about ants, and let us remember, since this is a tropical species, that naturalists have not yet nearly exhausted what is to be learned about our common Meadow Ant or Red Ant. There is in Florida and in the Tortugas a small reddish-brown ant called *Monomorium destructor*, really of East Indian origin. It well deserves its name of *destructor*, for it is a great pest in wooden buildings, making its nests in the chinks and crevices. Dr. Alfred Goldsworthy Mayor writes in publication No. 312 of the Carnegie Institution of Washington:—"So voracious are these insects that we are obliged to swing our beds from the rafters and to paint the ropes with a solution of corrosive sublimate, while all the tables must have tape soaked in corrosive sublimate wrapped round their legs if ants are to be excluded. These pests have the habit of biting out small pieces of skin, and I have seen them kill within twenty-four hours rats which were confined in cages."

Experiments were made in order to discover something reliable in regard to the way in which ants track their food. Recently killed houseflies were impaled on pins which were thrust into the wooden floor in the way of a wandering ant. If the ant's course brings it nearer the booty than a quarter-of-an-inch it suddenly turns and inspects its find, spending half a minute or more crawling over the dead flies and stroking them with its antennæ. It soon leaves them, however, without carrying off a fragment, but instead of moving in an erratic way, it goes in a fairly straight path toward some crevice in the floor. Out of this there soon issues an excited swarm of its nest-mates, who proceed towards the flies in a fairly straight path, not necessarily identical with that taken by the "finder ant" who brought the news. In many cases the path of the return swarm is not quite right, and thus the ants would pass to one side or other of the flies; but curiously, when the right distance has been traversed, and the ants are missing the flies, the swarm breaks up into scouting parties which course in random fashion in all directions, describing what

are technically called "Turner's curves." The file of ants seems to gauge the *distance* with great success, for Dr. Mayor never saw them miss it by more than two inches in a journey of eight feet. But they often miss the *direction* by as much as four inches to one side or other of the flies. Many of the scouts find nothing, of course, but others are successful, and within a few minutes a fairly straight swarm-path is established between the nest and the flies.

If a circle of corrosive sublimate solution be drawn around the "finder ant" when inspecting the booty the finder stops at the barrier on its home journey, but suddenly goes straight back to the dead fly. It starts again and stops again, and repeats the performance several times. Finally, it goes through the moat and reaches home. But when it meets its fellows and rubs antennæ with them they are not excited and no swarm comes back to the fly. Crossing the corrosive has spoilt the news.

If, when the swarm has started, a ring of corrosive be drawn around the fly, the ants coming from the nest are at once arrested when they reach the moisture. A block occurs, but in about a minute nearly every ant between the outside of the ring and the nest is seen to be returning home. If a "finder ant" is lifted and brushed it is incapable of conducting a return swarm to the fly. If a finder is injured, her nest-mates do not attend to her news. When the finder rubs antennæ with its fellows, intense excitement normally follows, and this spreads by contact. They crowd around the finder, and the probability is that it is the normal function of a "finder ant" to "personally conduct" her nest-mates back to the food she has discovered.

Free Choice of Food Influencing Egg Production and Weight.—Within uncertain limits we profit most by the food we like best. Other things being equal we are likely to get most good out of the food that attracts us most. This is partly psychological, no doubt, and partly because pleasant odours and tastes do actually help digestion. In this connection there is considerable theoretical interest in an important practical experiment made on poultry by Raymond Pearl and Thomas Everett Fairchild (*American Journal of Hygiene*, vol. i., No. 3, pp. 253-277). The experiment was designed to test what the effect would be on egg production and gain in body weight of permitting fowls to choose freely for themselves what kinds and amounts of food materials they would eat.

An experimental flock of sixty birds was allowed free access to some twelve different food materials presented to them at all times in hoppers, while a control flock, chosen to be as like the others as possible, was fed according to the system which years of experience had shown to be best. What were the results?

The free-choice birds ate more of the whole grain and less of milled products than the mass-fed birds. The free-choice birds consumed 33·4 per cent. less protein, 33·7 per cent. less fat, and had a total energy intake in calories 8·4 per cent. smaller than the corresponding consumption (including wastage) of the mass-fed

birds. The consumption of carbohydrate food was somewhat, but not greatly higher in the free-choice birds.

Thus there were considerable differences in the consumption of food, but the egg production, which was at a high level, and the gains in body weight, were substantially identical in the two groups. The conclusion appears justified that when fowls are allowed, within limits, complete freedom of choice in the kind and amount of the food they eat, they make a better physiological use of their rations. The free-choice birds ate less protein and fat, their total energy intake was less, but they were just as good in egg-production and weight as the control birds which were fed on the best system of diet that man could devise.

Bread Mould and Sex.—How often we have looked at mouldy bread without due respect, without sufficient imagination! It may turn out to be the material which will supply the solution of one of the deepest of biological problems—the nature of sex. What is the radical difference between male and female? Since the publication of "The Evolution of Sex" in 1889, we have adhered to the view there expounded, that the fundamental difference between the sexes is in the ratio or rhythm of metabolism—the vital processes of chemical change. The sperm-producer or male is an organism in which the ratio of down-breaking, disruptive, disassimilative (*Katabolic*) processes to up-building, synthetic, assimilative (*Anabolic*) processes is relatively higher than in the ovum-producer or female (k : a much greater than K : A). This view is suggested by many facts and supported by a few experiments. It is noteworthy that one and the same animal, such as a crab, can be changed from being a male to being a female. But there rises in one's mind the further question, what is it that makes the difference in the two ratios? The male animal and the female animal are remotely like two machines which differ in their gearing. What makes the difference in protoplasmic gearing?

Dr C. B. Davenport, director of the Institute for Experimental Evolution at Cold Spring Harbour, Long Island, New York, has recently said: "The phenomenon of two sexes runs through the world of organisms with a constancy that is hardly found in any other phenomenon. What is the nature of that protoplasmic dimorphism which is sex? One thinks of the double nature of matter—positively charged and negatively charged. One thinks of the dimorphism of certain organic substances, such as dextrose and levulose. Other hypotheses could be framed and doubtless have been."

One mode of attacking the problem is to find some creature in which sex has a very simple expression, in which it can be studied without the complications that are present when we think of horse and mare, peacock and peahen. The simple organism that has been for some years past attracting attention in connection with sex is the bread mould called *Rhizopus*. It consists of tangles of threads which under certain conditions may unite to form reproductive bodies. There are tangles of male threads through

and through and tangles of female threads through and through. But they seem to be the same, and yet we know that this cannot be the case. Dr Blakeslee has been trying to find out what is the invisible difference between male thread and female thread. If he succeeds he will have discovered the essence of sex. If the threads of two mould-masses that are of the same sex are brought together nothing happens. If the threads of two mould-masses that are of different sexes are brought together, they react by forming sexual bodies. *But what is the difference?*

The Abundance of Life.—We are all familiar with examples of the prolific multiplication of living creatures. From one grain of wheat how many grains? At the very heart of the organism is this capacity for capitalisation, and then using part of the riches to start new lives. The river of life is always tending to overflow its banks. Huxley calculated that *if* the descendants of a single green-fly all survived and multiplied, they would, at the end of summer, weigh down the population of China, which is probably about 500 millions. The common house-fly lays eggs in batches of 120–150 at a time, and may lay five or six of these batches during its life, which is only about three weeks in hot weather. At the end of summer, *if* all developed, the progeny of a single pair, with six layings, would occupy a space of something like a quarter of a million cubic feet, allowing 200,000 flies to the cubic foot. Yet there is no appreciable increase in the number of house-flies from year to year—therefore the mortality must be prodigious. It is quite different in the case of man, where there is an absolute increase in the population of the globe (1700 millions or so) amounting to 14–16 millions every year—a fact that makes one ponder.

But we were thinking merely of the capacity the living creature has to multiply its kind, and we came across a good example the other day. In Professor Reginald Buller's *Researches on Fungi* (1922) it is stated that the number of reproductive spores produced by a large mushroom is upwards of 10,000,000,000, that another fungus liberated about 30,000,000,000 spores in twenty-four hours, and that the spore-fall period had a duration of six months. Prodigious is the only word for it.

The biological significance is manifold. The whole economy of the animal kingdom is based on successive incarnations. The higher animals feed on the lower—the gull on the herring and the herring on the crustaceans—and the abundant multiplication of the lower makes the higher possible. In the long run, of course, the animals depend on the plants, and we see why the multitudinousness of the grass, for instance, is so fundamentally important. Then there is the intensity of struggle which the prolific multiplication often involves. There is the continual risk of the balance being upset. Deepest of all there is the question why this capacity of multiplying and of multiplying so abundantly is characteristic of living creatures. Crystals grow, but they do not multiply. Why among organisms does the one insist on becoming many?

A Startling Fitness.—We are all accustomed to the study of adaptations—particular adjustments of structure which suit particular uses. Every animal is a bundle of fitnesses. But sometimes the adaptation is positively startling in its subtle perfection. Let us take a recent case. There are minute Hymenoptera (the ant, bee, wasp order) which deposit their eggs, after the fashion of Ichneumon-flies, in the larvæ of certain gall-midges that are found in the wood-vessels of freshly cut trees in British Guiana. Three of these Hymenoptera have the egg-laying organ or ovipositor at the tip of the abdomen lengthened out so that it can reach the gall-midge larvæ within the wood. It is very interesting to find that this lengthening out of the egg-laying organ, studied by Charles T. Brues (*Proceedings American Acad. Arts and Science*, 1922, **57**, 263-88, 2 pls.) is in one case at least very variable. That is to say the structure is in a state of flux, and in the course of time there will be a survival of those types that are varying in the direction of longer ovipositors. For they will be most successful in reaching the larvæ in the tree. But here is the point. There is one genus called Inostemma where a very remarkable hollow horn arises from the back of the first abdominal ring and extends forward over the thorax ending with its blind tip just over the anterior eye-spot. What an extraordinary structure, like nothing else! It is confined to the female. Its meaning was discovered by a distinguished entomologist, Marchal, who showed that the hollow horn was a sheath for housing the very long ovipositor which would otherwise be in the way or get broken! It is a wonderful world.

AGRICULTURAL EDUCATION AND RESEARCH IN SCOTLAND.

ALEX. M'CALLUM, M.A., LL.B.

PART IV.

The North of Scotland College of Agriculture.

THE existence of the Fordyce Lectureship and the activities of the lecturer—Mr Thomas Jamieson—who held office from 1875 to 1895, led to the Government recognition of Aberdeen as a third centre of agricultural education in Scotland. The Lords of the Committee of Council for Agriculture made a grant of £100 to the Fordyce Trustees towards payment of the railway fares of the students attending the class of agriculture and agricultural chemistry conducted in Aberdeen University; and this was increased in 1889-90 by the second Board of Agriculture to £200 for general agricultural instruction. In 1892, when the Fordyce Trustees memorialised the Board in support of an application for increased grant to enable them to extend the lecture course, the Board suggested a reconsideration of the relationship between the Trust and the University. The result of this was an arrangement whereby, with the sanction

of the Scottish Universities Commission, the Fordyce Trust was merged among the other University Trusts, and the University Court thus became responsible for the agricultural instruction given under the trust deed.

In appealing to Government for increased grant in aid of agricultural education, the University Court pointed out that of the Scottish Universities, Aberdeen had assigned to it the largest of the three provinces into which the country was divided, that its valuation was the smallest, and that the district was the most expensive to deal with on account of the wide distribution of the population; while, at the same time, it had shown the greatest activity of any district in the country in the matter of agricultural education. The main feature of the Aberdeen work from 1877 up to that time (1892) had been the training of teachers in agricultural science, and this training had been encouraged by certain of the County Councils, notably Aberdeen, Ross, and Forfar, making grants to enable their teachers to attend the available courses.

The Court further pointed out that in the plans for the extension of the University buildings, then about to be commenced, provision had been made to accommodate a department of agriculture, and that it was their intention to equip it as fully as funds permitted.

The matter seemed of such importance that a Special Committee on Agricultural Education was appointed by the Court, and further action in relation to the Government grant and to future develop ments was remitted to this Committee. In accordance with the wishes of the Board of Agriculture the Committee made appeals to the provincial County Councils for financial assistance, the object in view being, as stated by the Board, the establishment of a thoroughly equipped school of agriculture as a centre of instruction for the North of Scotland.

Following upon this a scheme of operation was submitted to a conference of representatives of the northern counties, and was generally approved. Meantime the Court had promoted an ordinance to institute a degree of B.Sc. in Agriculture, and the curriculum for this degree was subsequently incorporated in the scheme. Eventually, promises of financial support were made by the Town Council of Aberdeen (£200), the County Council of Aberdeen (£200), the County Council of Banff (£25) and the County Council of Elgin (£20). These grants, together with the income of the Fordyce Trust (£40) and a grant from the University General Fund of £160, made up a total of available moneys from local sources of £645, and the Committee was now reconstituted with representatives of the contributing bodies upon it.

A condition of contribution had been made by the Councils that there should be a Lectureship on the Principles of Agriculture distinct from any Lectureship on Agricultural Chemistry. The Joint Committee accordingly decided that the Fordyce lecturer would be the proper person to hold the office of Lecturer on the Principles of Agriculture, and that a Lecturer on Agricultural Chemistry should be appointed separately. In advertising the post of Lecturer on Agriculture reference was made to a memorandum of duties in which it was explained that the object in view was to obtain the services of a lecturer well qualified to assist in the

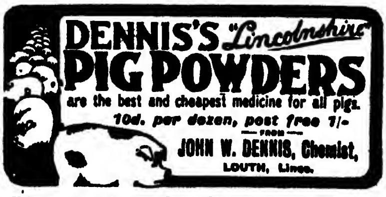
creation of a centre of agricultural education for the north-eastern counties by effective teaching in class, by advising with the Joint Committee on Agricultural Education, by conferring with agriculturists, and otherwise as circumstances might permit.

The first lecturer appointed on this new footing was Mr James Wilson, M.A., B.Sc. (Agric.) (Edin.), Lecturer in Agriculture in the University of Wales, Aberystwyth. Mr Wilson entered on his duties in January 1896. Later, Mr James Hendrick, B.Sc. (Lond.), F.I.C., Lecturer on Agricultural Chemistry in the Glasgow and West of Scotland Technical College, was appointed to the Lectureship in Agricultural Chemistry.

Following upon these appointments, the curriculum of classes qualifying for the degree of B.Sc. was determined, the applied science classes being principles of agriculture, agricultural chemistry, veterinary hygiene, agricultural botany, agricultural entomology, agricultural economics, and engineering field-work. The lecturer in agriculture undertook the teaching of economic science as applied to agriculture and of engineering field-work; Professor Trail that of agricultural botany and entomology, and Mr M'Lauchlan Young, M.R.C.V.S., was appointed lecturer on veterinary hygiene.

With the provision of class-room and laboratory accommodation in Marischal College and its gradual equipment as funds permitted, the centre as a teaching institution was now in working order. But so far it applied only to students taking the full degree course. The length of the course, the nature of the preliminary examination, and the amount of pure science required tended to shut out from the agricultural teaching many young men who might otherwise have contemplated attending. For these a shorter and simpler course seemed appropriate, and it appeared likely that they might be attracted and guided by such a course leading up to a diploma. A curriculum covering two winter sessions was accordingly drawn up, the subjects being principles of agriculture, agricultural chemistry, veterinary hygiene, agricultural botany, agricultural entomology, agricultural economics, and surveying and field engineering. Candidates for this diploma were obliged to sit a preliminary examination in general education before being admitted to the examination for the diploma. The diploma was instituted in 1897.

The efforts of the department at this stage were not confined to degree and diploma teaching. Special courses were held for teachers, the subjects being agriculture, botany, and chemistry; short courses for farmers were given in agriculture, chemistry, and veterinary hygiene; and the department co-operated with the Technical Education Committees of several counties in providing lectures in agriculture, agricultural chemistry, and veterinary hygiene. A certain amount of experimental work was also carried on, notably on the use and efficacy of tuberculin as a test of tuberculosis, the relation between human and bovine tuberculosis, on charlock destruction and on catch-crops, a grant of £20 a year for three years from Lieut.-Col. Innes and several grants from the Highland and Agricultural Society having stimulated action on those lines. Some experimental work on cereals, etc., was carried



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out by the staff on ground made available by the trustees of the Cruickshank Botanic Garden. The award of prizes presented by Mr Johnstone, President of the University of Winconsin, for stock-judging by the students gave rise to interesting competitions during the years in which they were held; as did also prizes presented by the London, Aberdeen, Banff and Kincardine Association for the best students in agriculture, chemistry, botany and veterinary hygiene.

The extra-academic work in the northern counties, it will be observed, was still practically untouched, and the Scottish Education Department kept pressing the Joint Committee for action in that direction. They, on their part, could do nothing without funds, and the funds were under the control on the one hand of the Department themselves and on the other of the local County Councils or Technical Education Committees. In replying to the Joint Committee's application for grant for the year 1899-1900, the Department pointed out that in distributing the moneys available among the various institutions concerned, they had to have regard to the amount of contributions from local authorities in the district as evidencing their appreciation of the usefulness of each institution. They accordingly proposed to invite the local authorities in the Aberdeen area to contribute towards the maintenance of the agricultural department, but before doing so, they asked whether the Committee would be willing to give a voice in the management of the institution to contributing counties.

In a later communication the Department, while recognising the value of the instruction given in the University classes and the importance of the research work carried on by the staff, reiterated their view that something more was wanted in the direction of bringing home to the agricultural community in the northern counties the results of agricultural investigation. They attributed this defect in part at least to the predominantly academic character of the institution, arising from its close connection with the University, of which indeed it formed an integral part, and to the relatively small influence exerted in its management by those who would be the natural representatives of agricultural interests. They accordingly indicated that the time was ripe for the setting up of an independent institution, more especially as under Article 98 of the Continuation Class Code the Department had now powers to pay grants to Central Institutions, not limited to fixed sums, but varying with the expenditure of the institution. The establishment of such an independent institution did not involve any complete severance of the connection with the university teaching, as arrangements might be made with the University to supply such parts of the instruction as might be agreed on. The Joint Committee were accordingly asked to invite the various local authorities interested in agriculture in the northern counties to send representatives to confer with the Joint Committee as to steps to be taken for the establishment in Aberdeen of an Agricultural College on the same footing as the colleges then existing in Glasgow and Edinburgh.

The definite assurance that, to obtain a continuance of grants,

the local centre must cease to be a department of the University, and must become a separate, self-governing college, satisfying the conditions of the Continuation Code and subject to the authority of the Scottish Education Department, made it clear to the Joint Committee that the basis of management and the scope of the institution under their care must be broadened and extended. A remit was accordingly made to a Special Committee to prepare a draft scheme of an institution such as that suggested by the Department. The draft scheme was circulated to the local authorities in the northern area, and being generally agreed to and approved by the Department, it was acted upon by the first meeting of Governors of the College being called for the 17th June 1904, in the County Buildings, Aberdeen.

This brought to an end the existence of the Joint Committee which had supervised the work of the department for twelve years. During the whole of that time the Rev. Dr Smith of Newhills acted as chairman of the committee, and to him much credit is due for his able guidance of its business, and for the keen interest and foresight he displayed in connection with agricultural education in the early stages.

The draft scheme of constitution provided for the institution of an Agricultural College whose object was to be the development in the north of Scotland of education and research in agriculture, forestry and allied subjects. The governing body was to consist of representatives of Town and County Councils in proportion to their annual contribution to the upkeep; of the University of Aberdeen, Robert Gordon's College, the Highland and Agricultural Society, and other bodies that might from time to time contribute to the funds; and additional members co-opted by the foregoing. Besides the carrying on of central classes, powers were taken specially for the provision of local courses, extension lectures, field and other experiments, and research stations and experimental farms.

The local authorities intimating support were the County Council of Aberdeen, £1200; the Town Council of Aberdeen, £400; the County Council of Banff, £300; the County Council and Committee on Secondary Education for Ross and Cromarty, £200; the County Council of Kincardine, £150; the County Council of Elgin, £100; Banchory Town Council, £20; Turriff Town Council, £10; Huntly Town Council, £10. The representation to the Governing Body was, in the first instance, fixed as follows:—The County of Aberdeen, 12; the City of Aberdeen, 4; the County of Banff, 3; the County of Ross and Cromarty, 3; the County of Kincardine, 2; the County of Elgin, 1; the University of Aberdeen, 5; the Highland and Agricultural Society, 2; and Robert Gordon's College, 1.

The first Chairman of the Governors was Mr Alexander M. Gordon of Newton; Dr James Campbell, Old Cullen, was Vice-Chairman; and Mr Wm. Murison, County Clerk, acted as interim Clerk and Treasurer.

In 1912, the constitution of the governing board was modified in order to permit the representation of all the County Councils and County Secondary Education Committees in the college area, and

the College was then incorporated under licence of the Board of Trade, and registered under the Companies (Consolidation) Act, 1908.

Mr Gordon had retired from the chairmanship of the Board of Governors in 1911, and he was succeeded by Dr (now Sir) James Campbell. The late Mr R. H. N. Sellar, Huntly, held the office of vice-chairman from 1911 to his lamented death in 1918, since when the position has been filled by ex-Bailie Wilkie, Aberdeen.

Previous to the constitution of the College, Mr James Wilson had resigned his tenure of the Fordyce Lectureship, and had been succeeded by Mr R. B. Greig [1] in February 1903. The staff as taken over by the College thus consisted of Messrs Greig (Agriculture, etc.), Hendrick (Agricultural Chemistry), M'Lauchlan Young (Veterinary Hygiene) and Professor Trail (Botany and Entomology). The governors immediately increased the staff by the appointment of assistants, and took up the question of extension work in the counties. There was a feeling that a special effort should be made to supply instruction to the agricultural districts more distant from Aberdeen, and, to begin with, the County of Ross and Cromarty was dealt with by the appointment of a resident lecturer, Mr George Esslemont, to act in consultation with the governors representing the county. A secretary, part of whose charge was the reorganisation of the extension work, was appointed, Mr George Hendry being the first holder of the office, and Mr William Murison continued to discharge the duties of treasurer.

So far as the holding of the central classes was concerned, accommodation continued to be provided in Marischal College and, for certain classes, in Gordon's College, while secretarial accommodation and rooms for meetings were obtained in the County Buildings. The arrangement with the University provided for the class-room and laboratory accommodation, heating, lighting, etc., being given free, and for the continuance of the contribution by the University of £200, including the income of the Fordyce endowment.

The whole fees—matriculation, class, diploma and degree—were paid to the University, while the salaries of the College staff and the charges for material and apparatus were met by the College. The appointment of members of the teaching staff, so far as related to the in-college work, while in the hands of the governors was subject to confirmation by the University Court.

This working arrangement was revised in 1910, when it was settled that the use of rooms in the University by the College should continue to be rent free; that the University should continue to pay towards the salary of the Lecturer in Agriculture the net revenue of the Fordyce endowment; that the governors should pay annually to the University a sum of £300 to meet charges such as lighting, heating, water supply, taxes, insurance, etc.; that the University should receive all class and other fees, but should hand over to the College the fees applicable to the classes taught by College officers; that the salaries of all lecturers and assistants connected with the work of the College should be

[1] Now Sir Robert B. Greig, Chairman, Board of Agriculture for Scotland.

paid by the governors, as well as all charges for apparatus and materials; that the said lecturers and assistants should be appointed by the governors, subject to confirmation by the University Court, and should have the status of University lecturers or assistants.

These and other terms of agreement were declared to be subject to alteration on due notice.

The details of this agreement have been given, as they present a remarkable example of a business-like compromise which has proved wonderfully successful in its actual working over a series of years.

When, in 1921, a considerable addition had to be made to the accommodation of the Department to cope with increased attendance of students, the annual payment made by the governors to the University was increased, but otherwise the agreement was unaltered.

A further example of this harmonious co-operation between University and College was given when the beneficent gift of £10,000 by Lord Strathcona permitted the endowment of the Chair of Agriculture. It was then agreed that this sum and also the funds of the Fordyce bequest, then amounting to £1710, 15s. 6d., should be applied to the endowment; that the occupant of the Chair should also act as lecturer in the College of Agriculture and should receive therefor such remuneration as the governors might fix; and that the patronage of the Chair should be vested in a body of seven curators, of whom three should be appointed by the University and four by the College; the Principal of the University to be one of the University representatives and to be chairman of the curators. This arrangement was embodied in the ordinance establishing the Chair which was approved by His Majesty in Council on 3rd October 1911. A later bequest by Lord Strathcona added, in 1915, a sum of £5000 to the endowment of the Chair.

Mr Greig resigned the Fordyce Lectureship in May, 1910. In view of the imminent establishment of the Chair, a temporary arrangement was made whereby the duties of the lectureship were discharged during sessions 1910-11 and 1911-12 by Mr J. M. Caie, a member of the College staff, now assistant secretary to the Board of Agriculture for Scotland. The first, and present, occupant of the Strathcona-Fordyce Chair is Professor James Hendrick, appointed in 1912, who continues to give the courses in agricultural chemistry, and also acts as Director of Studies and of the Research carried on by the College. The teaching of the subject of agriculture was otherwise dealt with by the appointment of Mr W. J. Profeit as lecturer.

So far the extension work of the College had been largely carried on by the members of the central staff, with the addition of a resident lecturer in Ross and Cromarty and one instructress in poultry keeping for the whole area. As the result of a conference between representatives of the College and Dr Struthers of the Education Department, a new scheme of operations was adopted, the main feature of which was to be the appointment of an organiser in each county to carry out extension lecturing, conduct

systematic classes, supervise experiments, advise farmers, and consult with school boards and teachers on the establishment of school gardens and instruction in elementary agricultural science. Suggestions were also made by the Department for the training in agricultural science of rural school teachers and for the training of special instructors for service in the crofting areas. Attention was also called to the need of an experimental farm for the College, and it was intimated that the running expenses of such a farm would be regarded as a legitimate charge upon College funds.

This scheme was adopted in entirety by the governors in May, 1908, and was gradually brought into operation. Mr George Esslemont was appointed general organiser with the duties of preparing a syllabus of extension work, assisting the county organisers to arrange programmes, supervising the dairy and poultry work, superintending experimental sub-stations, advising school boards in regard to school gardens, supplementary class work, and continuation classes in agriculture and horticulture, and reporting generally on all aspects of the College extension work. The College area was divided into nine districts as follows:—

(1) Kincardine; (2) East Aberdeen; (3) West Aberdeen; (4) Banff; (5) Moray and Nairn; (6) Eastern Watershed of Inverness and Ross; (7) Sutherland and Caithness; (8) Orkney and Shetland; (9) West Coast and Islands of Inverness, Ross and Sutherland. In each district a Local Advisory Committee was appointed to assist the county organiser in planning his work, the organiser acting as secretary. The Advisory Committee in each case included the governors of the College for the district, a representation of resident farmers, and others interested in the work of the College. Three county organisers were appointed immediately and the others as trained men became available. Dairy and poultry instructresses were also appointed.

With the object of reporting upon the working of school gardens and of experimental farms attached to Agricultural Colleges in England, a deputation of governors and staff made a tour of a number of English centres in the summer of 1908, and reported favourably on the aims and results of these adjuncts to the teaching equipment of a College, and emphasised the necessity of providing a farm near Aberdeen for the use of their own institution and of at least two ten-acre areas for experimental purposes in the outlying parts of the college area.

When the question of a particular farm was taken up the governors found that the estate of Craibstone, a few miles north of the city, was available and a proposal was made and adopted that the mansion house on the estate might be utilised as a training school for girls, on the lines of the Munster School in Ireland. In the crofting and small farming districts of the North of Scotland the work of women is of special importance and the governors were impressed with the need for providing instruction of this type. In order to obtain information and guidance in drawing up their plans they appointed a deputation to visit the Irish schools of this sort, and also the National Dairy School at Kilmarnock. In Ireland the deputation visited the Munster Institute, Cork; the School of Domestic Economy, Loughlynn; and the Ulster Dairy School,

Cookstown. They reported favourably as to the merits of the training given in these institutions and also as to the suitablility of Craibstone.

These deputations having duly reported, the governors decided to lease the home farm and the mansion house and policies, provided suitable terms could be arranged. The proprietors, a body of trustees incorporated by Act of Parliament, were willing to lease, but an investigation of the subjects revealed that a sum of at least £6000 would have to be expended to make them suitable for the purposes of the College. It seemed therefore to the governors that an expenditure of such an amount would be justified only in connection with property over which they had at least an option to purchase; and while the trustees were willing to sell it was found that under the constitution of the trust they had no powers to do so. This difficulty however was got over by the promotion of a Provisional Order. Pending the actual purchase of the property a lease of the home farm, the mansion houses, and the policies, with entry as at Martinmas 1910, was arranged.

There was the further and more serious difficulty of obtaining funds for purchase and equipment. But fortunately this was made possible by the establishment of the Development Commission Fund and the arrangement come to by the Development Commissioners, the Scottish Office, and the Treasury for the provision of funds for agricultural development in Scotland. The North of Scotland College put forward an application for a grant in aid of the acquisition of Craibstone and its adaptation and equipment for the purposes of the College. The capital necessary for purchase, etc., was made available on the basis of one-half from the Development Fund and one-fourth from the Education (Scotland) Fund, provided the College obtained the remaining one-fourth from local or non-Government sources. Appeals to local authorities and the Carnegie Trustees were generously met, and the estate was acquired in 1915 at a purchase price of £17,890. The plan of utilisation, including alterations to the farm buildings, the mansion house, furnishings, equipment of dairy, laundry, etc., and stocking of farm, brought the total estimated cost up to £25,000.

Meantime, the Development Commission and the Board of Agriculture for Scotland in their scheme of organisation of agricultural research in Scotland had allocated to Aberdeen the problems of animal nutrition; and a Joint Committee of University and College representatives had been formed in February 1913. The intention was to provide accommodation for the work on animal nutrition on the Craibstone Estate.

These plans for development had to be postponed during the War, and for several years later. As a residential centre of training for ex-service men in agricultural work Craibstone proved most useful and from 1919 to 1921, 176 trainees passed through courses intended to fit them for agricultural employment.

When the training of these ex-service men came to an end, the governors once more took up the project of utilising Craibstone as a residential training institution for young women. It so happened that at this time the building which had been erected at Craibstone immediately before the war, to house the work of the staff of the

Nutrition Institute became available for purchase from the Joint Committee on Research. That committee through the beneficence of Dr John Quiller Rowett and with the aid of a generous grant from the Development Commission were enabled to embark on a much larger scheme of operations, involving the acquisition of a new site and the erection of greatly extended premises. Consequently their first building was acquired by the College and has been adapted to provide accommodation for the dairying and laundry departments of the Rural Domestic Economy School. This adaptation and the equipment of the mansion house, the farm-steading, and the poultry department were sufficiently advanced to permit the school to be opened in July of the current year. The curriculum is intended to cover instruction in all branches of women's work on the small farm. The period of training has been tentatively fixed at six months, though this may be modified in the light of experience. Much of the training is practical in character and embraces the subjects of dairying—including feeding and management of cows and calves, and the treatment and utilisation of milk—poultry keeping, pig keeping, household work—including cookery, needlework and laundry—gardening and bee keeping.

The venture has the hearty support of the education authorities in the College area who have agreed to award bursaries to enable suitable students to attend the courses.

The farm and policies at Craibstone are largely utilised for experimental and demonstration work. While field experiments of the usual character are conducted in connection with the general management of the farm, special work is carried out on experimental plots. The drainage investigation conducted by Prof. Hendrick is the only one of its kind in Scotland; the demonstration and breeding plots under the charge of Mr Findlay form an exceptionally interesting feature; and the garden and the apiary are admirably arranged.

In the original plan for the development of the estate, forestry was to have a special place. That industry is of highest importance in the north-eastern counties and the College from its foundation paid special attention to the subject. In 1907 Mr William Dawson was appointed Lecturer in Forestry; a department was gradually built up; and, later, degree and diploma courses were instituted. Mr Dawson resigned in 1913 and was succeeded by Mr Peter Leslie. Through the generosity of Dr. J. E. Crombie of Parkhill a University Lectureship in Forest Botany and Entomology was established. When Craibstone estate was acquired, one of the objects in view was the establishment of a small demonstration area or forest garden. During the war and subsequently, a great deal of useful work was done in growing forest trees from seed for the replenishment of depleted plantations. The establishment of the Forestry Commission in 1919 transferred the responsibility for forestry instruction to that body from the Board of Agriculture for Scotland and as a result of lack of funds to carry on the department in the College it had in 1923 to be handed over to the University, although a certain amount of experimental and demonstration work continues to be located at Craibstone.

Besides the provision of a central farm, the scheme of develop-

ment promoted by the College in 1908 included the establishment of subsidiary demonstration farms and crofts in other parts of the college province. Considerations of expense have delayed the full realisation of the scheme, but the College have been fortunate in offers made by proprietors of small farms to be used in this way. Thus in 1909 offers of crofts were made to the College on behalf of Mr C. W. Dyson Perrins of Ardross and Mr Murray of Lochcarron; and eventually in 1910 the governors agreed to lease the croft of Balnaguisich, of about 23 acres, near Alness, with a view to carry it on mainly as a poultry demonstration croft, to conduct experiments in ascertaining the best breed of poultry for crofting conditions, to illustrate proper methods of poultry keeping, to provide for the supply of sittings of pure-bred birds, and to utilise it as a centre of instruction in poultry matters generally. At the same time some demonstration on farm crops and live stock would also be possible, all with a view to crofting conditions. In 1920 the croft, which has been conducted with much success, was given to the College by Mr Dyson Perrins in feu for an annual nominal payment of £1 so long as it continues to be utilised for demonstration purposes on the present lines.

The College have in view the establishment of similar demonstration stations in other districts, but so far financial and other considerations have prevented this. Another form of demonstration is that of agricultural plots—the seeds, manures and other materials for the cultivation of which are supplied by the College to selected farmers or crofters in different districts, the farmer supplying the land and the labour necessary. Results obtained on the plots are demonstrated to the neighbours, and in this way a knowledge of newer varieties or methods is spread. College fruit plots in Kincardineshire and Ross-shire are utilised for demonstrations in planting, thinning, summer and winter pruning, spraying, etc.; and in the case of eight school gardens scattered over the area, small annual grants are made on the understanding that the gardens are worked on the lines laid down by the College, and are available for demonstration purposes. The training of teachers in school gardening is part of a rural school course provided by the College, the practical gardening work in which is undertaken at the College Garden at Rubislaw, Aberdeen.

The aims set forth in the Scottish Education Department's 1908 scheme have been thus to a large extent attained. There is the Central College well housed, equipped and staffed, with its demonstration station and residential school at Craibstone, and its garden at Rubislaw, and there is the extension staff, most of the members of which are resident in the various counties, with the College demonstration croft at Alness and the numerous demonstration and experimental plots all over the area. Thus, whereas in 1904 the staff taken over from the Joint Committee consisted of the Fordyce Lecturer in Agriculture, the lecturer in Agricultural Chemistry and the lecturer in Veterinary Hygiene, together with a part-time lecturer in Botany and Entomology, there is now a staff

at the Central College of eleven lecturers, ten assistants and two research officials; at the School of Rural Domestic Economy a staff of three; and in the counties an extension staff of nineteen organisers and assistant organisers, and fourteen instructresses; besides the administrative and the farm staffs. As regards the administrative staff it should be mentioned that the first secretary, Mr Geo. Hendry, died in 1916; that Mr Wm. Murison acted as interim secretary until the beginning of 1921, when the duties were undertaken temporarily by Mr G. S. M'Combie who, however, was obliged to resign through ill-health, and that Mr A. A. Prosser was appointed to the post in June 1921. Mr Murison's long and efficient services to the College were recognised by his being unanimously co-opted as a governor.

With such an organisation the College is now carrying on many varied activities and exercising a wide influence on agricultural practice and development in the north and north-east of Scotland. It is not possible to catalogue in full detail the various activities; only a brief notice can be given, and further details must be looked for in the calendar and in the reports and bulletins issued by the College.

The central classes provide, besides the courses for the degrees and diplomas in Agriculture and Forestry, special courses for those intending to take the National Diploma in Dairying or a diploma in Poultry-keeping; a Farmer's Course of one winter session not qualifying for either degree or diploma, and evening classes during the winter. Mention has already been made of the courses in School Gardening for teachers in training, and these are supplemented by vacation courses for acting teachers. For some years after the war special courses, intended to prepare young men for posts on rubber, tea, coffee and cotton plantations in the East were given, but owing to lack of demand for such men under the prevailing conditions the courses have been dropped meantime.

To encourage attendance at the full courses of training the College is fortunate in having placed at its disposal a number of useful bursaries. In 1915 Dr Campbell, the Chairman of the Board of Governors, in order to signalise his long connection with the interests of agricultural education in the north of Scotland, gifted a capital sum of £3000 to establish four bursaries of £30 a year, each tenable for two years. Two of these are awarded annually at the close of the winter session to students who have taken the first year subjects for the B.Sc. degree or the diploma in Agriculture.

The Hunter Bursary and Prizes, founded by the late Mr James Hunter, Banchory, are awarded annually for the best essays on prescribed subjects. The William Alexander Bursary of £6 a year, tenable for three years, was founded by his widow in memory of Dr Alexander, and is awarded preferably to a student of that surname, the son of a small holder in the parish of Chapel of Garioch, Aberdeenshire. The Joseph Fraser Bursaries,

three of £40 per annum, were founded as a memorial of the late Mr Joseph Fraser, a planter in Ceylon, and are intended to assist students who propose to train for the career of planter in Ceylon. In addition to these College bursaries there are the Milne Bequest bursaries, and the usual Education Authority bursaries granted by County Authorities to students resident in each county.

The staff of the College have from its inception endeavoured to combine with their teaching activities as much research work as time and opportunity permitted. Reports of this work have been published from time to time as College bulletins or otherwise, the subjects dealt with including tuberculosis in cattle, effects of liming, qualities of basic slag, composition of farmyard manure, effects of electricity on crops, the production and composition of kelp, and numerous other problems. Mention may be made specially of the investigations into bee disease which resulted in the discovery by Dr Rennie and Mr Bruce White of the acarine disease causation as related to Isle of Wight disease, and of Professor Hendrick's work on soil drainage. Recently the College have appointed an Advisory Officer on Soils, whose main work is the investigation of soil types in the north-eastern area. Research work on animal nutrition is now carried on at the Rowett Institute under a Joint Committee representing the University and the College.

FARM PESTS.[1]

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Natural History Department, Royal Scottish Museum.

Mammal Pests—concluded.

The Destruction of Rats—continued.

(3) POISONING. Where rats are present in considerable numbers about a farm poisoning is the most effective method of getting rid of them. It may be regarded either as a first stage in a rat campaign, to be succeeded by trapping when the number of rats has been seriously reduced, or as a full campaign in itself to be prosecuted till the rats have been exterminated. Mr T. Munro has sent me the following note on this subject:—

"Poisoning is undoubtedly the quickest method of reducing the number of rats about a farm steading or in the fields and hedgerows. There is little danger to domestic animals if the poison is laid so that they cannot obtain access to it. Farmers are very chary of laying down any poison in their farm steadings, not only on account of the risk to their stock, but also because of the losses which sometimes occur amongst their cats. Cats do not

[1] Earlier articles of the series appeared in this *Journal* for July and October 1922, and January, April and July 1923.

often obtain the baits, but they catch and devour rats suffering from the effects of poison, from which they also die. If poison is laid all cats should be placed in restraint for three days from the date poison was laid. A careful search should be made in the vicinity, and rats should be found destroyed and the carcases burned or buried.

"To make a poisoning campaign a success rats must be attacked in numbers. It is advisable to feed them for perhaps a week, then mix poison with the material they have been fed on and provide a plentiful supply. No poison toxic to rats and harmless to domestic animals has yet been discovered. Red squill, either in liquid extract or powder form, is perhaps the poison least dangerous to domestic animals, but it will destroy them if they obtain a sufficient quantity. A single application of poison is ineffective; it requires to be repeated at intervals of a month until no rats remain."

Many poisons are available either already prepared for use in proprietary preparations, or suitable for home preparation. Of the former Mr R. Sharpe recommends "Sanford's rat poison," a quantity of which applied to a small pebble he rolls well within each burrow. No bait is necessary, and the mode of application places the poison outside the reach of domestic animals. He insists that to ensure success the whole ground to be cleared of the pests must be treated in a single day. The best poisons for home-made preparations are barium carbonate and red squill, and of these the latter was found during the London Zoological Gardens experiments to be most useful, first because it was three times as deadly for rodents as barium carbonate, and secondly because it was even less harmful to most domestic animals, although both are much less deadly to these than phosphorus or arsenic.

Red squill may be obtained as a powder or in liquid extract. The powder may be made up as follows: Red squill powder, 1 part by weight; fine oatmeal, 2½ parts by weight; dripping, 1½ parts by weight. Melt the dripping and mix thoroughly with it the dry ingredients to form a thick paste. A small teaspoonful of this mixture should be wrapped in a twist of tissue paper or placed on bread and inserted in each burrow. The liquid form of red squill should be mixed with an equal quantity of milk and bread, to a quantity of 8 lbs. for each gallon of the solution, should be soaked in the mixture, and used as a bait. This liquid preparation was found to be more consistently effective than the red squill powder mixtures, when tested in the London Zoological Gardens.

Tests made with rat viruses, which consist of cultures of bacillus microbes giving rise to disease in rats, have shown that the results are so variable that such preparations cannot yet be recommended as sure cures for rat plagues.

(4) Fumigation or gassing is of particular value where rat burrows are plentiful and otherwise inaccessible, and where no danger is likely to arise to human beings, domestic stock or food material from its use. Mr Munro remarks regarding this method:

"Gassing either with sulphur dioxide or chlorine is an effective method of destroying rats and any young rats which may exist in nests in the burrow. The evening before gassing is to be done it is desirable to close lightly all the holes in the burrow to be gassed. This will prevent a waste of time and a waste of gas on rat holes which may be temporarily uninhabited. Only those holes which have been opened in the interval should be attended to. Prejudice exists against chlorine as too dangerous for use. So long as this gas is not applied in a building or other enclosed space, it can be used freely. The small quantity which may be inhaled while working in the open is negligible. Chlorine in a liquid state can be obtained in steel cylinders of a portable size which are fitted with a tap and nozzle. A flexible steel pipe, ¼ in. diameter, is attached to the nozzle, and conveys the gas from the cylinders. Should the tap be frozen (by the chlorine), hot water

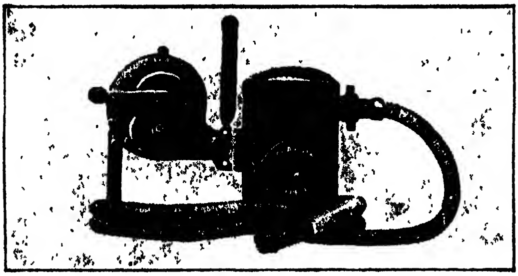

FIG. 1.—Clayton Fumigating Machine (Notyalc Pattern).

poured over it or a cloth wrung out in hot water may be applied. As chlorine is heavier than air, all the holes in the burrow, except the highest, should be closed, and it also should be closed as soon as chlorine escapes through it. The gas must be allowed to flow gently through the burrow for 10 to 15 minutes; it is advisable to remove and replace from time to time the pieces of turf closing the ends of the rat holes to make sure that gas is passing through all the runs. Chlorine is a pale yellowish green gas which in a very short space of time turns vegetation straw coloured. The change in colour of the grass will indicate where the gas is escaping; this should be prevented. The operator should always place his appartus to windward, and above the locality to be gassed. Chlorine is most effective, but more costly than sulphur dioxide as a fumigant.

"Sulphur dioxide gas is produced by burning sulphur. Fuel consisting of rags, brown paper, oily waste or other material is ignited, placed in a receptacle and brought to a red glow; sulphur, powdered or broken small, should be sprinkled over the fuel, and the container closed securely. Air must be supplied to the burning mass by bellows, fan or other means to secure the combustion of the sulphur and to drive the fumes into the burrow.

A smoke test machine, such as is used by sanitary officers for testing drains, is suitable for producing this gas, or a Clayton gassing machine may he obtained. The procedure to be adopted is the same as when using chlorine."

A recently devised Clayton fumigating machinc is here illustrated. In contrast to the large apparatus in use for disinfecting warehouses, docks and such like, this pattern, specially devised for the destruction of vermin, is comparatively small, portable and easily worked; it measures 24 in. × 10 in. × 16 in., and weighs 32 lbs. Among other advantages of this machine are that it

FIG. 2.—Clayton Fumigating Machine in use for Destruction of Rats on a Poultry Farm.

produces a highly concentrated, and therefore highly effective, sulphurous gas, and that the essential material for charging it, refined roll or rock sulphur, is cheap and readily obtainable.

A simpler and cheaper home-made apparatus, manufactured from an old paint-drum and a few accessories, is illustrated in Leaflet No. 244, *The Destruction of Rats*, published by the Ministry of Agriculture and Fisheries, where it is said that it "can often be used to fumigate the rat runs in banks and hedgerows, and under fowl houses and styes."

(5) HUNTING may be prosecuted in rat-infested land with the aid of a ferret to cause the rats to bolt, when they are shot or clubbed, or killed by dogs; but the most familar rat hunt takes place in the stackyard when stacks are being taken down for

threshing. In such conditions as many as 5000 rats have been killed at a threshing on a 2000 acre farm near Chichester and, while it is to be hoped that so great need for slaughter is exceptional, the opportunities afforded by threshing should be made the most of. It has been suggested that to this end a temporary rat-proof fence 4 feet high, say of wire-netting or corrugated iron, should be placed around the stack about to be threshed. Within this limited enclosure the killing of the rats with sticks or by dogs is reduced to comparative simplicity and certainty.

It cannot be too often asserted that the destruction of rats is a matter for organised effort over as large an area as can be worked in the necessary detail. Isolated effort in a limited area is more likely to result in a migration, more or less temporary, to a less disturbed neighbourhood, than in the extermination which should be the ultimate end of all destructive measures. Over and over again it has been shown that effective co-operation between neighbouring tenants or throughout an administrative area has produced results which individual efforts could never equal. I need give only one example. In 1909 East Lothian farmers clubbed together and employed four rat-catchers to work the whole county; in 1910 two men were employed; in 1911 the County Council took over the work and seven rat-killers were engaged; in 1912 the area was restricted and the number of rat-catchers reduced to three; but the total result of these combined efforts was that in the six years, 1909 to 1914, 116,857 rats were killed, 70,000 of these being accounted for in the last four years.

The Common or House Mouse.—As a destroyer of stored goods and property the House Mouse (*Mus musculus*) makes a very good second to the rats. This little greyish-brown denizen of human habitations, called by the French on account of its colour the "Grey Mouse," is, like the rats, an invader from foreign lands, which has followed the steps and colonised the habitations of man to the ends of the earth. As a rule house mice prefer to dwell in buildings, but in many countries and in summer in our own land some of their numbers may take to the open and flourish in the fields. In houses their nests, made of tiny fragments of paper or other material they may find it convenient to gnaw, are to be found in snug corners of presses, shelves or boxes, and there, if undisturbed, litter may succeed litter throughout a great part of the year. As a rule a litter contains five or six young, and the rapidity with which mice multiply may be gauged by the facts that the period of gestation is just under three weeks, that mating takes place immediately the young are born, and that the young themselves, at first blind and helpless but able to leave the mother in three weeks, are themselves sexually mature at the age of three months.

Economic Importance.—Mice, as everyone knows, feed upon all sorts of human food, and upon stored goods which provide even

the least trace of nutriment. Notwithstanding that the damage caused by one individual is almost negligible, the cumulative destruction, caused directly by the devouring of grain and such like, and indirectly by the pollution of food materials by droppings, in places where mice are permitted to increase unduly, may become very serious. The damage thus caused in the bags of wheat which lay stacked upon the quays of Australian harbours during the Great War, became a byword in a nation whose wheat allowance at the time was severely rationed, and Mr Hinton records that the actual damage, apart from the defiling of the grain which was salved, exceeded £1,000,000. He says, "The mice were in billions. One farmer put down poisoned meat in his house and next morning he picked up 28,000 dead on his verandah, and he added that he only stopped then 'because he was tired.' At one wheat yard 70,000 were killed in an afternoon." Could a more effective illustration be found of the danger of house mice uncontrolled?

It has already been pointed out that rats take an important part in the spread of certain diseases amongst domestic stock and human populations, and mice share with rats this unenviable notoriety. The spread of trichinosis amongst pigs and plague amongst men has been laid at their door, and the use of grain, fouled by mice, for human food or even for the use of domestic animals is stated by Mr Hinton to be attended with grave risks.

The Destruction of Mice.—The methods most effective for the exclusion and destruction of rats have been discussed in these articles in some detail, and much that has been there said applies with equal force to the destruction of mice. The natural enemies of mice, owls and weasels in particular, should be protected, and the domestic cat may be encouraged with great effect. Breeding places should be destroyed, food materials and stored goods protected in mouse-proof containers as far as possible, and where mice show signs of serious increase a determined campaign against them must be carried out. A cheap and effective mouse trap of the nipper type has already been illustrated (fig. 6, p. 306), but other types, such as the old-fashioned block mouse trap with circular holes or traps of the ever-set type, are available and, where mice are not too numerous, trapping may reduce their numbers sufficiently. But where they occur in great numbers and the plague cannot be checked at its source by the destruction of breeding places poison may have to be employed. In such a case the poisons recommended for rats may be used, but the dose actually employed should be reduced by half. On account of its high fatality to rodents and its comparative harmlessness to domestic animals the preparation of red squill already described for rats will be found particularly useful. Finally, it is well to remember that mice are much less cunning than rats and appear to be less ready to read a lesson from the fate of their fellows, so that both to trap and to poison they fall victims more easily than their larger relatives.

REPUTED PESTS HAVING THE BALANCE IN THEIR FAVOUR.—Having concluded these notes on the mammals which, by their varied activities and in their different ways, levy toll upon the farmer, I might regard my task as completed; but simple justice demands that something more should be said. From these pages certain common animals have been omitted, which are almost universally regarded as pests and treated as such—the weasel and the stoat, the badger, the hedgehog and the shrews. To pass these over in silence would be to abandon them to their fate, and such a fate they certainly do not merit. It must be kept in mind that it is not always a simple matter to determine a pest; there is as a rule a mixture of good and evil in every creature, and it is not enough for the condemnation of an animal to prove that it does harm. The question we have to answer before judgment can be pronounced is not "does it do harm?" but "does it do more harm than it does good?" Having asked this question, having balanced the good against the evil in the light of the accumulated knowledge of animal habits, I have reached the conclusion that in the case of these reputed pests the balance unmistakably swings in their favour. But, lest this finding should meet with disapproval on mistaken grounds, let it be made quite clear that I am not concerned here with the question of game-preservation but solely with the relationship of these creatures to farming.

The Weasel and the Stoat.—As a certain amount of confusion appears to exist between these two representatives of the musteline group of the carnivores, and as, particularly in parts of the Lowlands, the stoat is invariably called "weasel" or perhaps more commonly "hweasel," it may be well to point out a few clear distinguishing marks. Both Stoat (*Mustela erminea*) and Weasel (*Mustela nivalis*) possess the same long, lithe, ferret-like body, and in summer both are very similar in colour—reddish-brown on the upper surface of the body and on the outer sides of the limbs, and yellowish-white on the under parts and inner sides of the limbs. The two creatures are easily distinguished, however, by their size and by details of coloration. The stoat is considerably the larger, its length from tip of snout to tip of tail measuring about 16 to 18 inches, while the corresponding length of the weasel is 9 to 11 inches. Of this difference a great part is due to the different length of the tail in the two species, for whereas the length of head and body alone in the stoat is about 9 to 11 inches against the weasel's 7 to 8¼ inches, in the former the tail measures 6½ inches and in the latter only 2½ inches. Colour also gives a safe guide for differentiation, for at all seasons of the year the tip of a stoat's tail is black, while that of the weasel is of the ordinary body colour, never black. The general colour of the weasel, moreover, is of a redder hue than that of its relative.

Now, although in summer the colours of the two species are similar, in winter, as a rule, they differ almost as black from white; for, throughout Scotland, the majority of the stoats assume a white

coat during the winter, the only trace of summer's livery being the persistent black tip of the tail.

Economic Significance of the Weasel.—The weasel is wholly carnivorous, feeding in the open country largely upon young rats, mice and voles, which it hunts with extraordinary persistence, and in their season, upon the eggs and young of birds, in search of which it may climb trees. It is true that it may destroy the eggs and the young of partridges and pheasants, and that occasionally and generally under the stress of hunger, it may enter the poultry yard or hen-house and destroy some of the inhabitants. But it has often been known to enter stack-yards and even barns and granaries in pursuit of rats and mice, and there can be no doubt that in destroying the greater part of its food supply it is performing an unqualified service to the farmer. On farm land the weasel

FIG. 3.—STOAT—in summer coat.
(From Bell's *British Quadrupeds*).[1]

ought to be encouraged and protected; but this is not to say that a weasel found guilty of damage in the poultry-yard should not be slain. The chances are that such an individual may be a "rogue," which has developed a rather unusual taste, and that its destruction will remove all cause of complaint. It would be absurd, however, to slay the innocent and useful because of the occurrence of an occasional "black sheep."

Economic Significance of the Stoat.—The habits of the stoat closely resemble those of the weasel, but its greater size and strength make its depredations more formidable. It may pursue and bring to the ground hares and rabbits; it may destroy game birds—pheasants and partridges, even grouse and ptarmigan, and their eggs may afford it dainty fare; and it may attack poultry and suck their eggs. Indeed many of the ravages attributed to the weasel are much more likely to have been

[1] Figs. 3 and 4 are due to the courtesy of Messrs Gurney & Jackson, Edinburgh and London.

caused by the stoat. Yet such can hardly be said to form normal diet of stoats. Their ordinary food consists largely of rats, field mice, voles, small birds and, during the nesting time, birds' eggs. In season and out of season they carry on their beneficient labours in the fields, by dyke-side and hedge-row, with a blood-thirsty zeal that brings to book far more vermin than they devour. Is this not to be accounted to them for good? Have we not already shown that rats, rabbits and mice are amongst the farmer's worst foes. So far as the farmer is concerned I have no hesitation in classifying the stoat. Although it stands nearer the border-line between good and evil than does the weasel, although the balance swings a little before it makes its final plunge, it does assuredly come to rest in favour of the persecuted stoat. In general, stoats should be encouraged; and, as in the case of the weasel, the rogue individual caught in the act, or found loitering with intent about the poultry-yard, may safely be left to be dealt with by the man on the spot.

The Badger or Brock.—For long ages the Badger (*Meles meles*) has been an object of persistent persecution in this country, first in order that it might be made the object of the barbarous sport of badger-baiting, and second because of a widely-spread notion that its ways are harmful to the welfare of man. The once universal sport is dead, and here in the interests of truth I hope to drive a nail in the coffin of the almost universal belief. For the belief in the general harmfulness of the badger bears no relation to the balance of facts. To what then is it due? In the first place it has been nourished on the peculiarities of the animal itself, its large size, its fierceness when brought to bay, and its mysteriousness, for the badger is not only a nocturnal beast, remaining in close hiding during the day, but, since it hides underground, it is so seldom seen, that frequently the presence of a badger family in a district is revealed only by the traces of some food-hunting expedition.

The definite misdeeds alleged against the badger by its opponents are these. It has been known to kill lambs, it has been known to destroy game-birds and their eggs, it has been known to kill poultry, and, a grevious fault in some districts, it is said to kill young foxes, though in most parts of Scotland this propensity, for what it amounts to, must be reckoned to the badger's credit. Now though these delinquencies be admitted, there is good evidence that they are not regular habits, they are occasional lapses from virtue due to excessive hunger, excessive temptation or, at the worst, to a rogue individual which has cultivated unfortunate tastes.

On the credit side of the account, against these occasional trespasses, are to be reckoned the normal feeding habits of the badger. It is perhaps the most miscellaneous feeder amongst British animals: to its credit must be put all the young rabbits it devours, all the moles, rats, mice, voles, frogs, as well as slugs, harmful beetles and other insects. The remainder of its food, and

it is vegetarian as well as carnivorous, consists of fresh shoots and berries when they are available, but more usually of various roots of wild plants, mushrooms, and indeed almost any vegetation that is convenient; and such activities may be regarded as neutral, affecting the farmer neither one way nor the other.

It must be apparent from this summary, that if the badger cannot be said to be a mainstay of British farming, it at least does more good than harm. Its activities are mainly beneficial or neutral; it may be safely left to its own devices; it ought certainly not to be persecuted and destroyed. Appeal may more readily be made for this relic of the old Scottish fauna, a link with the bears to whose family it belongs, because in past times destruction for its flesh and its skin and ill-considered persecution have reduced its numbers to but a fraction of its former abundance, and have ultimately banished it from many districts in which a hundred years ago it was familiar.

The Hedgehog.—The Hedgehog (*Erinaceus europaeus*) is by structure a member of the group of insectivores, but by nature its diet sweeps far beyond the insect limit. It is safe to say, however, that its food is predominantly animal, and that although it has been stated to eat such miscellaneous plant-stuffs as apples and wild berries, acorns, turnips and fungi, these can form but an occasional and very rare contribution to its dietary. In any case, in devouring what vegetable food it does, (I myself have never seen evidence of vegetarianism) the hedgehog remains neutral, it it takes no side either for or against the farmer.

The remainder of its feeding is wholly partisan; many regard it as one of the worst of vermin, others find much of weight to say in its favour. I hope to show that it is on the whole an ally of the farmer.

Let us look first at its misdeeds. They are admitted and they are serious. We have passed the stage when it was believed that during the night hedgehogs sucked dry the udders of cows in the meadow. That myth may be left to garnish the works of credulous ancients. But other faults are only too well vouched for. Undoubtedly it devours the eggs and young of ground-nesting birds. The outcry made against it is loudest when these are the eggs and young of game-birds, but that need influence the farmer only in so far as these birds are insectivorous, unless indeed he unites the incongruous duties of game-preserving and farming. More serious for him is it when the victims are ground-nesters of agricultural value, such as corn-crakes and skylarks, for these also have been known to suffer; or when a hedgehog ventures to attack the eggs and chickens of the poultry yard.

What can be put into the balance against these admitted and serious misdeeds? The fact that the hedgehog is an insectivore, and still largely depends on diet of invertebrate pests! Its regular and normal food consists of beetles, the grubs of insects, worms, snails and slugs. Beyond this lowly fare it regularly devours mice and young rats, young rabbits and frogs. All this must be set

down to its credit, and the final decision must depend on whether the credit side of the account out-balances the debit.

On the whole we must come to the conclusion that throughout the run of the year the normal, regular food must out-balance in quantity and in importance the specialised delinquencies, although many examples of these have been recorded. (No one troubles to record a day's or a week's labour amongst the injurious insects of field or garden, many rush to record a destroyed clutch of pheasants' or partridges' eggs). A fair sample of the hedgehog's food throughout the year clearly indicates that the balance falls in favour of the despised "urchin." It is a creature that the farmer, for the sake of his crops, ought to spare.

Shrews or Shrew Mice.—Three kinds of shrew mice occur in Britain, the Common and the Lesser Shrew (*Sorex araneus castaneus* and *Sorex minutus*) and the Water Shrew (*Neomys fodiens bicolor*). Although these are all nocturnal in habit, and are seldom

FIG. 4.—THE COMMON SHREW.—A useful creature, once thought to cause cattle disease.

(From Bell's *British Quadrupeds*).

seen for this reason, and because the former two favour hedge-rows and dry meadows where they remain concealed in their grassy runs, while the last inhabits its own system of tunnels on the banks of a stream, they are subject to a certain amount of ill-considered persecution. Since nothing in their habits gives ground for any enmity on the part of man, his hostility must be set down to the half-concious persistence of an ancient myth that, as one writer puts it, the shrew mouse is "a kind of field mouse . . . . very mischievous to cattel; which going over a beast's back, will make it lame in the chine; and the bite of it causes the beast to swell at the heart and die." Needless to say, there is as little truth in this strange tale as in the stories of the mysterious "earth-hound" which still survive in Aberdeenshire, and appear to apply to this creature.

In fact shrews are perfectly harmless both to man and to his domestic stock. Not only are they harmless, but all their activities

go to aid the farmer. They have insatiable appetites, but their hunger is confined to insects and their grubs, worms, and the smaller slugs and snails.

Since shrews are often confused with mice, it may be well to state that they are readily to be distinguished by their more slender build, their long pointed snout fringed on both sides with a row of long whiskers, long tail, squarish in section, covered with short and close stiff hairs, and numerous (thirty-two) tiny insectivore teeth, with tips coloured reddish brown, which contrast strongly, both in number and shape, with the sixteen rodent-type teeth of mice, with their characteristic chisel-like incisors.

AGRARIAN CHANGES IN POLAND.

H. M. Conacher.

As elsewhere in Central and Eastern Europe, the foundation of a new or rather (in the case of Poland) the revival of an old State has led to a demand for State action to enable the peasantry, who are now too numerous to derive a living from the land so far possessed by peasants, to obtain more land in the only way possible—*i.e.*, by the expropriation of large landowners. For one reason or another it was less possible for the will of the peasant majority to attain satisfaction in such fashion under any of the former alien governments, under which the Polish people lived; even in Galicia, or "Little Poland" as the Poles call it, where the Poles had more autonomy under the relatively decentralised régime of the late Austro-Hungarian Empire than in Russia or Prussia, no drastic legislation of this kind would have been possible. The Sejm, or Diet, however, which assembled in Poland after the war, was very much dominated by the peasant deputies and they were interested in the distribution of land more than in any other political question. Even outside the peasant class there was a recognition of the desirability of meeting this demand, as being a means of checking the heavy emigration from Poland which has gone on for many years. This process was something more than the normal emigration to America, or than the seasonal migration of Italian and Spanish workmen north of the Alps and Pyrenees. In addition to Polish emigration to America, numbers of Polish labourers were in the habit of migrating to other European countries as permanent labourers, or at least to stay abroad for a number of years. If they are not particularly welcome to the masses of the Western Countries that they go to, it is equally true that this exile is not for the Poles a life of their own choice, especially as they compete at a certain disadvantage in the labour market in the countries of their exile. As the new Poland, or at least those of its citizens whose political consciousness is active, are a little uneasy at the neighbourhood of two out of the three powers which formerly

partitioned the older Poland, and as national safety is still thought of in political circles as being dependent on large armies, it is not unnatural that this continual emigration of Poles from Poland should be generally regretted. Further, Poland is not on the whole an industrial State; it has now a part of Upper Silesia, but this area has taken its own labouring population with it. There are also the textile industry of the former Kingdom of Poland and salt and oil in Galicia. All this, however, does not mean that Poland is more industrial than Italy or France. Hence the surplus numbers of the peasantry do not find their way into the towns. Again, apart from the emigration abroad, the peasantry who remain on the land are there in too great numbers and continued subdivision tends to make the peasant holding less of an economic unit.

The land question in Poland is usually considered with reference to agrarian conditions of the three parts of Poland formerly incorporated in the three Empires implicated in the partition; *i.e.*, the Kingdom of Poland, or Congress Poland, which after 1815 had a semi-autonomous position in the Russian Empire up to 1863, Prussian Poland and Galicia. The new Polish State, however, also includes part of White Russia acquired in terms of the peace of Riga, and part of Lithuania, especially the Government of Vilna. It is true that the old Polish State was united to Lithuania, but since the war Lithuania has been a separate State. Poland, however, has managed to attach a part of it to herself by means and under circumstances with which we are familiar. Eastern Galicia, too, is now formally attached to Poland; but this area is on a different footing and was a fairly integral part of the former Polish State. If ever the Ukraine, including Little Russia and South Russia, becomes an independent State, it may have something to say of the future of Eastern Galicia, which is Ruthenian, and also of Carpathian Ruthenia attached to Czecho-Slovakia, as it certainly will with regard to that part of the Russian Government of Volhynia recently annexed by Poland.

For the present, however, it is necessary to confine our attention to the purely Polish Poland in considering the basis of the agrarian reform. Congress Poland, or Russian Poland, is the largest of the three areas and contains about 8 million hectares[1] of cultivated land out of a round total of 12 million hectares. The restored parts of Prussian Poland, West Prussia, Posen, parts of Upper Silesia and East Prussia contain about $4\frac{1}{2}$ million hectares of such land, including forests and moors. Galicia has a total area of 8 million hectares, of which a quarter is forest land and the rest mainly cultivated. Apart from the portions of Galicia which rise towards the Carpathians, the greater part of Poland is plain land; except so far as it is under forests it is mainly cultivable and has been cultivated for centuries. It is, in fact, one of the considerable grain-growing areas of Europe, and the grain, of which the export formed a good part of the old

[1] A hectare is equal to about $2\frac{1}{2}$ acres.

Baltic trade, was largely grown in the valley of the Vistula. In recent times the main cereals grown have been rye and oats and to a less extent wheat and barley; the potato area has been extensive in Russian and Prussian Poland. Rotations are fairly simple and the alternation of root and forage crops with the growth of cereals has not gone far in Poland; nor, indeed, has dairying as a separate branch of stock-breeding.

This maintenance of traditional agriculture is connected with the rural economy of Poland, to which is also due the land question. In other words there has been no fundamental change, in many parts of Poland at least, since the adjustments were made at the date of the liberation of the serfs. This happened as late as 1864 in Russian Poland, in 1848 in Galicia, and in 1823 in Prussian Poland—at least this last is the date when the agrarian reforms, which Stein initiated in Prussia in 1809, were applied to the Polish provinces. Under all the settlements the peasants were made landholders in respect of the land which they had formerly occupied in the "manors," or their local equivalents, in which they had lived. Their former lords were left in possession of their demesne lands, which, however, they had to work henceforth without servile labour. Under these circumstances, the large landowners do not seem to have achieved in their lands the same progress in agriculture which has been attained in this country by letting land in equipped holdings to professional capitalist-farmers or by the occupying ownership of the more prosperous peasant of Germany, the "bauer," and certain western countries. Equally the peasant land became too restricted as it was divided into too small holdings with the growth of population. Hence in all parts of Poland the peasant has sought to obtain more land and the only land available has been that possessed by the large landowner. Prior to the war he did this by economic pressure, to a certain extent furthered by State activity. Thus in Russian Poland the Peasants' Bank facilitated the transfer by buying land and selling it to peasants. In this way about 600,000 desiatines (a unit fairly near the hectare) passed into the possession of the peasants in the later years of the nineteenth century. The "mir" with its collective husbandry does not exist in Russian Poland. The peasant commune is called the "gmina," and the peasant at least holds his arable in severalty.

In Prussian Poland a curious process went on. The Prussian Government had set up an Ansiedlungs Commission to buy up the estates of Polish landowners and divide them among German colonists. The Polish peasantry, however, who had learned a great deal under Prussian rule, organised a very successful movement for buying up land in Posen and West Prussia, and on the whole they were more successful than the official Prussian organisation. In Galicia the peasants acquired a certain amount of land; but the peasant land is, on the whole, very congested through subdivision.

In Poland the large landowner does not usually own a single continuous estate divided into a number of farms. He owns

rather a number of isolated "farms," each in what was a separate manorial unit. As that unit also contains the peasant "gmina" or village, there is nearly always at hand an obvious supply of land upon which the overcrowded peasant commune seeks to encroach. Further, the peasants of any one commune have in their minds the fact that the large landowner of their neighbourhood has other lands elsewhere, and regard him as a pluralist. It is in this atmosphere that the general demand of the peasants for land has inspired the recent Acts of the new Polish legislature. The land reform is embodied mainly in two Statutes passed in 1919 and 1920 respectively by the Polish Sejm. The former Statute expressed the nature of the desired reform rather in outline, while the latter filled in details and elaborated the machinery. The purpose of the legislation was stated to be the creation of a reserve of land for internal colonisation. Such a reserve was to be created in the first instance by assigning for that purpose various publicly-owned classes of land, such as the public domain, the lands in the possession of the former Russian Peasants' Bank and the Prussian Colonisation Commission, lands belonging to ecclesiastical corporations, and, lastly, the lands belonging the private landowners. Among the latter were to be taken by preference certain types of land, such as those that were badly cultivated or had been acquired during the war, or recently changed hands twice otherwise than by inheritance, or were under "fidei commissa" or trusts. No definite maximum amount of land in private property was specified in the Acts to be taken as was done in the corresponding legislation in other countries, and certain language was used which implied that the Sejm rather contemplated as a distinct policy that the land of Poland should pass mainly into the hands of occupying owners. Certainly the amount of land which a landowner was entitled to hold immune from compulsory expropriation was not very large, varying according to the intensity of cultivation of the district from 60 to 180 hectares.

If that was the intention of the Sejm, no great progress has so far been made in the direction of a general redistribution of land, and that for reasons which will soon be made clear. The work of carrying out the reform was left largely to a Central Land Office, which has at least a dozen district offices in different parts of the country. The Land Office plans and carries out the actual schemes of settlement, and takes the initiative in acquiring the land of private persons as apart from the public lands of various kinds, (many of which were administered by the Ministry of Agriculture) placed at its disposal.

One cannot say that the two laws made by the newly constituted Polish Diet bore marks of crude drafting and construction. Generally, the provisions made a coherent whole and not many things were overlooked, but there were certain features in the procedure for taking land which would strike persons living in constitutionally governed countries as abnormal. Thus the Land

Office is not under a Minister responsible to Parliament. Its President is appointed by the President of the Republic on the recommendation of the President of the Council of Ministers, but he is not, strictly speaking, a member of the Council except for the acts of his own office. The opponents of the legislation, who are active, attack this semi-irresponsible position of the Land Office. Certainly it looks as if the peasant majority, whose views inspired the legislation, was determined to have machinery which should "get something done," and not act under the usual checks. At the same time the sanctioning authority for taking land compulsorily is not the Central Land Office but the Central Land Commission, half of whose members are members of the Diet, and the other half judicial and legal experts and agriculturists. This is supposed to be an administrative and judicial body. It has also local commissions under it which decide on applications of the Central Land Office or its branch offices for the exercise of compulsory powers. Their decisions may be appealed to the Central Commission. The judicial actings of the Commission are justiciable before administrative tribunals which exist in Poland to try cases arising between the State and individual citizens.

Another curious provision of the law was that if land was taken compulsorily, the owner should only get as compensation half the market value. This provision has been quoted in Czecho-Slovakian documents to prove the greater moderation of their own corresponding provisions. One can only imagine that the Polish legislators must have heard of the tendency in some countries for expropriated landowners to get unusually liberal terms of compensation. The provision is, perhaps, more intelligible if it is kept in view that the landowner who stands out for compulsion has the chance at the outset of coming to terms with the Land Office, and that in any case he only has to submit to compulsion after many appeals. Certainly the provision was intended to avoid making landowners resort universally to compulsion. Under voluntary agreement the landowner was to be paid compensation as fixed by expert valuers.

The administrative Courts have made two important decisions—

(1) That the provision as to half the market value is unconstitutional;

(2) That the Land Office must exhaust every other source of supply of available land before taking compulsorily the land of private persons.

These decisions have tended to retard the progress of land settlement.

One naturally asks how the Courts were in a position to make the former of these decisions. The Sejm which passed the two laws was rather in the nature of a national assembly. After passing them it proceeded to draft a constitution which was adopted in May 1921. Apparently, anything in the earlier legislation which was at variance with the fundamental laws of the constitution could be set aside. This provision, which came

into Court, seems to have been held to be of this character. By the end of 1921 about a quarter of a million hectares had been settled, partly by the Land Office, partly by approved institutions acting under the Land Office, and partly by private persons likewise so acting. These other methods do not seem to have been contemplated by the laws, but apparently experience has satisfied the Land Office that it can make better progress in this manner.

It is probable that the legislation will be revised. The reform has not been carried out as quickly and in as drastic a manner as the peasants hoped. On the other hand, the reform has excited great opposition in other classes, not only among large landowners, but partly among professional men. Further, those who look for revenue from agriculture are disturbed at the possible effect on agricultural production of a wholesale division of the large estates among peasant landholders. This apprehension is, perhaps, the more natural, as the country called upon the agriculturists of all classes to make great efforts (which have been largely successful) to bring back production to its pre-war level in a country much ravaged by the war. At the same time statistics of production in Congress Poland before 1914 tend to show that for certain crops peasant agriculture was almost as productive as capitalist agriculture.

FARM WAGES AND WORKING HOURS IN SCOTLAND IN SUMMER 1923.

SIR JAMES WILSON, K.C.S.I.

The Scottish Journal of Agriculture, in its issue for October 1922, contained an article by me on "The Fall in Farm Wages," which gave such information as was available regarding the changes which had taken place up to Whitsunday 1922. In continuation of that article, I now offer a rough estimate as to the effect of the changes made at Martinmas 1922 and at Whitsunday 1923, so far as can be gathered from the *Monthly Agricultural Report* for June 1, issued by the Board of Agriculture, and from the reports regarding the result of the hirings given in the newspapers and in the *Scottish Farm Servant*. It will be understood that in the absence of definite schedules from individual farmers, the estimate can only be an approximate one. I confine attention in the first instance to the case of the ordinary married ploughman, excluding grieves and foremen.

In calculating the value of the allowances, which in many counties form a considerable part of the total earnings of married ploughmen, I have followed the rule adopted by the Central Agricultural Wages Committee, namely, that the value to be placed upon them should be ordinarily the wholesale price current in the district—the price taken in the case of potatoes being that current at the time when the main crop was lifted. As no information is at present available to enable local wholesale prices to be

estimated, I have assumed for this purpose for the whole of Scotland the following values—house and garden, free of rent and rates, £5 per annum; oatmeal, per stone, 2s. 8d.; potatoes at the time the last main crop was lifted, £2 per ton; potatoes in the drill, £3 per 1600 yards; milk, per gallon, 1s.; coal, per ton, £2; cartages, per annum, £1.

Married Ploughmen.—In the greater part of Scotland married ploughmen are usually engaged for a year from Whitsunday, but new bargains are made every Martinmas with the married ploughmen in the industrial area in the centre of the country stretching from Dundee to Ayr.

The Lower Clyde Valley.—In the Lower Clyde Valley in the neighbourhood of Glasgow, comprising parts of the counties of Lanark, Dumbarton and Renfrew, and in North Ayrshire, the married ploughmen are engaged for a term of six months, and the proportion of their earnings paid in allowances is comparatively small. In summer 1914 their average weekly earnings seem to have been about 24s. (cash 20s., allowances 4s.). In summer 1921 they were at their maximum, about 63s. (cash 58s., allowances 5s.); but during the following eighteen months, owing to the great fall in the cost of living and to the prevalence of unemployment, the average cash wage fell by about 21s., and during last winter the average wage of the ordinary married ploughman was about 41s. (cash 37s., allowances 4s.). Little change seems to have been made at last Whitsunday, and this may still be taken to be the value of the average total earnings during this summer.

The Eastern Industrial Area.—In the eastern part of the central industrial area, which comprises Fife, South Forfar and the Lowland part of Perthshire, the married ploughmen are generally engaged for the year from Martinmas, and most of them have, besides their cash wages, large allowances in oatmeal, milk and potatoes. In 1914 the average earnings of a married ploughman in this area seem to have been about 24s. (cash 18s., allowances 6s.). During the period of rising prices, the cash wages rose rapidly, and at the same time the value of the allowances increased, until in summer 1921 the average earnings were about 60s. a week (cash 46s., allowances 14s.). In November 1921 there was a reduction in the average cash wage of about 12s., and again in November 1922 there was a further reduction of about 7s., and, as the value of the allowances has also fallen, the average total earnings in this area may now be estimated at 37s. per week (cash 27s., allowances 10s.).

The South-Eastern Counties.—In the south-eastern agricultural counties, comprising Linlithgow, Midlothian, East Lothian, Berwick, Roxburgh and Dumfries, the married ploughmen are engaged at Whitsunday for a whole year, and their allowances, consisting chiefly of a house and potatoes, form only a small proportion of their total earnings. In 1914 their average earnings appear to have been about 22s. per week (cash 19s., allowances 3s.). In summer 1921 the average was about 52s. a week, varying from

50s. in East Lothian to 53s. in Midlothian and Linlithgow. At Whitsunday 1922, owing to the great fall in prices and to the prevalence of unemployment, there was a large reduction in the cash wage, amounting on the average to about 13s., as compared with the previous summer. At last Whitsunday little change was made in the rate of cash wages, and the present average earnings of a married ploughman in these six counties appear to be about 37s. 6d. (cash 34s., allowances 3s. 6d.), but vary from 36s. (cash 33s., allowances 3s.) in East Lothian to 40s. (cash 37s., allowances 3s.) in Linlithgow.

In Peebles the present earnings seem to average about 40s. (cash 36s., allowances 4s.). In Wigtown, where the allowances are high and the cash wage correspondingly low, the present earnings appear to average about 36s. (cash 24s., allowances 12s.).

The North-Eastern Counties.—From the northern part of Forfarshire northwards along the East Coast, the married ploughmen are mostly engaged for a whole year from Whitsunday, and are given large allowances in kind. In the seven counties, Forfar (North), Kincardine, Aberdeen, Banff, Moray, Nairn and Inverness (East), there was at Whitsunday 1922 a large fall both in the average cash wage and in the value of the allowances; but little change seems to have been made at last Whitsunday, and the present average earnings of a married ploughman in those counties may be estimated at 36s. (cash 25s., allowances 11s.).

Little information is available regarding the Northern Counties or the West Highlands, but there also there was a large fall at Whitsunday 1922 and little change at last Whitsunday. In Sutherlandshire the present average earnings of the married ploughmen appear to be about 32s. (cash 20s., allowances 12s.), and in Caithness 29s. (cash 16s., allowances 13s.)—the lowest in all Scotland.

Summary.—I append a statement giving estimates based upon the available information as to the present average earnings of married ploughmen, county by county. This estimate may be compared with the similar estimate given for summer 1920 on page 49 of my printed report on "Farm-Workers in Scotland in 1919–20," and with the estimate made for last summer on page 408 of *The Scottish Journal of Agriculture* for October 1922.

Taking these estimates as they stand, they give an arithmetical average for the 25 counties mentioned of 37s. 3d. (cash 29s. 10d., allowances 7s. 5d.), which may be compared with the corresponding average for summer 1920 of 53s. 9d. (cash 41s. 5d., allowances 12s. 4d.), and with the corresponding average for last summer of 40s. 1d. (cash 32s. 10d., allowances 7s. 3d.), the reduction since last year having taken place last Martinmas chiefly in those counties in the central industrial area where the married ploughmen are re-engaged for the year from Martinmas. It is generally reported, however, that both at last Martinmas and last Whitsunday those married ploughmen who stayed on in their former employment and made their bargains with their employers at

home secured better terms than were got at the hiring fairs by those men who changed their places. I venture, therefore, to estimate that for all Scotland the present average weekly earnings

AVERAGE WEEKLY EARNINGS OF MARRIED PLOUGHMEN IN SUMMER 1923.

County.	Cash.		Allowances.		Total.	
	s.	d.	s.	d.	s.	d.
Wigtown	24	0	12	0	36	0
Dumfries	32	0	4	0	36	0
Roxburgh	32	0	4	0	36	0
Berwick	34	0	4	0	38	0
Peebles	36	0	4	0	40	0
East Lothian	33	0	3	0	36	0
Midlothian	36	0	3	0	39	0
Linlithgow	37	0	3	0	40	0
Stirling	38	0	3	0	41	0
Dumbarton (Lower Clyde Valley)	37	0	4	0	41	0
Lanark (Lower Clyde Valley)	37	0	4	0	41	0
Renfrew (Lower Clyde Valley)	37	0	4	0	41	0
Ayr (North)	37	0	4	0	41	0
Fife (East)	27	0	11	0	38	0
Perth (Lowland)	27	0	10	0	37	0
Forfar (South)	27	0	10	0	37	0
Forfar (North)	27	0	10	0	37	0
Kincardine	26	0	11	0	37	0
Aberdeen	25	0	11	0	36	0
Banff	25	0	10	0	35	0
Moray	25	0	10	0	35	0
Nairn	25	0	11	0	36	0
Inverness (East)	25	0	11	0	36	0
Sutherland (East)	20	0	12	0	32	0
Caithness	16	0	13	0	29	0
Average of twenty-five Counties	29	10	7	5	37	3

of married ploughmen (excluding grieves and foremen) are about 39s. as compared with 22s. in summer 1914, with 55s. in summer 1920, and with 42s. in summer 1922, an increase of about 77 per cent. as compared with summer 1914. According to the *Labour Gazette's* statistics, the cost of living is now (July 1923) 69 per cent. above what it was in July 1914, so that it would appear that, on the whole, the married ploughmen in Scotland are still in a position to maintain their families at a standard of comfort at least equal to that which they had attained immediately before the war, more especially when it is remembered that many of the houses occupied by them are now worth in renting value considerably more than £5 a year, and that in this calculation the allowances have been reckoned at much lower values than the retail prices which have to be paid by the ordinary British working-man. Few married farm-workers have failed to obtain re-engagements, any reduction that has been made in the number of farm-workers having been made chiefly at the expense of the single men.

Single Men.—In the south-eastern counties the single men, like the married men, are mostly engaged for the year from Whitsunday; but in the rest of the country, even where the married men are engaged for a year, the single men generally are engaged for six months only, and have to make a new bargain every Whitsunday and Martinmas. In the case of single ploughmen it is difficult to strike an average, because (1) some of them, besides their cash wage, receive board and lodging in or near the farm-house, while others live in bothies and receive allowances similar to those received by the married ploughmen, but less in quantity; and (2) the wages paid to single men vary greatly according to their varying experience and capacity. According to returns received from farmers, in the winter of 1919-20, 550 single ploughmen over the age of twenty-one received cash wages averaging 35s. 1d. per week and allowances, including board and lodging which were then valued at 11s. 2d. per week, making their total average earnings 46s. 3d. per week compared with 50s. 3d. per week then received by the married ploughmen. Both at Whitsunday 1922 and at Martinmas 1922 there was a considerable fall in their cash wages, and again at Whitsunday 1923 it is generally reported that a further reduction took place in the cash wages of single men of from 1s. to 2s. a week. In the counties in which it is usual to give board and lodging to the single men, there is a concensus of reports to the effect that the present cash wage of those men is approximately 20s. a week, though in some counties, such as Wigtown, Dumfries, Lanarkshire (Upper) and Stirling, a lower average of wages is reported, while in other counties, such as Dumbarton, Aberdeen, Banff and Moray, the rates averaged about 21s. a week. In Orkney it is said that ploughmen accepted less than 10s. a week with maintenance.

In September 1920 the District Wages Committees valued the board and lodging for an adult man at rates varying from 14s. per week in the north-eastern counties and Moray Firth districts to 21s. per week in the Border counties and in Forfar and Perth, the arithmetical average being 17s. 9d. Since then the cost of living has fallen considerably, and the value of board and lodging for an adult man may now be taken as about 14s. on the average for all Scotland. This, with the cash wage at an average of 20s. a week, would give the average total earnings of an unmarried ploughman for all Scotland as about 34s. a week, as compared with 39s. a week for the average married ploughman. From the reports published it is evident that during the last two years the cash wages of the single men have been lowered to a greater extent than have those of the married men, and that a larger proportion of the single men than of the married men have failed to obtain employment; though, even in the case of the single men, the proportion of agricultural workers who have failed to obtain employment on farms is much less than the proportion of unemployed men in many other industries. There are indications that a considerable number of unmarried male farm-workers in

Scotland are now emigrating to Canada, the United States and Australia.

Women Workers.—In the south-eastern counties (Roxburgh, Berwick, East Lothian and Midlothian) it is common to employ women to work in the fields, engaging them for a year from Whitsunday at a cash wage fixed at so much per week, plus a harvest fee of from £1 to £2, and sometimes a small allowance of potatoes. These additions may be reckoned as worth about 1s. per week for all the year round. In 1914 their average earnings seem to have been about 13s. a week. In summer 1920 they had risen to an average of about 30s. At Whitsunday 1922 there was a general fall of about 8s., but little change has been made at last Whitsunday. The cash wages vary from 20s. to 24s. per week, and the average earnings of the women outworkers in these four counties may be estimated at present as about 22s. per week (cash 21s., allowances 1s.) In the rest of the country women working on farms, on other than temporary engagements, are generally employed as dairymaids or kitchenmaids, and are boarded and lodged in the farm-house. In some areas the supply of such women has been insufficient, and there has been little reduction this year in the rate of wages paid them. In most areas in the centre and south of Scotland an experienced kitchen-maid is paid a cash wage of about £20 for the half-year, and experienced dairymaids in Stirling, the Lower Clyde area and Ayrshire get from £20 to £25 for the half-year. Inexperienced girls have had to be content with less—say, from £15 to £20; and from Orkney it is reported that the cash wage of girls is from £8 to £10 for the half-year.

Working Hours on Farms.—In 1919 and 1920 a considerable reduction in farm working hours took place in a great part of the country, especially by the adoption of the nine-hour day in summer, and of the Saturday half-holiday, except in busy seasons. In 1922, and again this year, there has been a movement among the farmers in several counties for an increase of the working hours, and this movement has met with some success, especially in the directions of having the working hours reckoned from stable to land's end in place of reckoning them from stable to stable, and of making the working hours during harvest ten per day for six days a week. At Whitsunday this year a crisis arose in East Lothian, where the history of this question has been as follows:—

East Lothian Working Hours.—At a Conference, held on 20th February 1920, it was agreed to recommend for East Lothian a detailed time-table, according to which the working hours (reckoned from stable to stable) should be for 32 weeks a 50 hours' week—that is, 9 hours a day on ordinary week-days and 5 hours on Saturday; for 4 weeks at seed-time a 54 hours' week of 9 hours a day, including Saturday; for 6 weeks at harvest-time a 58½ hours' week of 9¾ hours a day, including Saturday; and for 10 weeks in winter a shorter working day

reduced to a 41½ hours' week in the darkest fortnight of the year. This time-table allowed for a half-holiday on Saturday in 42 weeks—that is, in every week except the 10 weeks of seed-time and harvest. A workman who engaged on these terms bound himself to work during the year an average of a little less than 50 hours a week, reckoned from stable to stable. In 1921 engagements were made approximately on these conditions, except that the farmers stipulated that time should be reckoned, not from stable to stable, but from stable to land's end. In 1922 the same hours were worked. This year the farmers began by proposing that no change should be made in the wages, but that 3 hours more work should be done each week. The Farm Servants' Union strongly opposed this proposal, and, after lengthy negotiations and the threat of a strike, it was finally agreed between the representatives of the farmers and farm servants that the question should be referred to arbitration, the question for the arbiter to decide being "whether the time-table for 1922–23 is to stand, or whether the number of hours for 1923–24 should be increased, and if so, to what extent, but the total number of increased hours are not to exceed 95 hours per annum." The arbiter's decision was that "the working hours should be increased by 20 for the year to Whitsunday 1924, as may be most conveniently arranged by the parties themselves," and he suggested that the additional hours to be worked could probably be most conveniently added to the Saturday's yokings. A new time-table for farm work has been drawn up in accordance with this decision, and agreed to by both parties. The working hours will be reckoned from stable to land's end, that is, from the time at which the horses leave the stable to the time at which work stops in the field. Any interval allowed for meals will not be reckoned as working time. During 18 weeks in spring and summer the working hours will be 50¾, that is, 9 hours on 5 days in the week and 5¾ hours on Saturdays. On ordinary week days the horses will leave the stable at 6 a.m., there will be an interval of 15 minutes for breakfast, and work will stop in the field at 11.15 a.m. In the afternoon the horses will leave the stable at 1 p.m., and work will stop in the field at 5 p.m. For 4 weeks in seed-time the week will consist of 54 hours, that is, 9 hours on 6 days, including Saturdays. During 6 weeks in harvest the week will consist of 58½ hours, that is, 9¾ hours a day for 6 days, including Saturday. The horses will leave the stable at 6 a.m., and work will go on in the field till 6 p.m., 15 minutes being allowed for breakfast, 1¾ hours for dinner, and 15 minutes for tea in the afternoon, but not reckoned as working time. For 6 weeks in October and November the week will be 50¼ hours, that is, 9 hours on 5 days a week and 5¼ on Saturdays. During 18 weeks from November to March the day's work will depend upon the length of daylight, and will average 46¾ hours, being reduced during the last fortnight of December to 41¾ hours, the morning's work then being from 7.45 to 11.45, without any

allowance of time for breakfast, and the afternoon's work from 1 p.m. to 4.30. This table allows, as before, for a half-holiday on Saturday in 42 weeks, that is, in every week except the 10 weeks of seed-time and harvest; and on all half-holidays work on Saturdays will cease at 12 noon. A workman who has engaged on these terms has bound himself to work during the year an average of a little less than 50½ hours per week, as compared with the 50 hours agreed upon in 1920, and the working hours, instead of being reckoned from stable to stable according to the 1920 agreement, will now be reckoned from stable to land's end. This alteration in the method of reckoning working hours, taken by itself, means an increase, as compared with the 1920 agreement, in the time actually spent on work in the field of about 20 minutes on each ordinary working day, and 10 minutes on the Saturday half-holiday—say, about 100 hours in the year, because the time spent in coming back from the field to the stable no longer reckons as part of the working time, as it did in 1920. The time spent in going from the stable to the field is still, however, reckoned as working time.

An agreement was also reached on a number of other questions in East Lothian. A married ploughman will, in addition to his cash wage, have a free house and garden, and 4 bolls (that is, 16 cwt.) of potatoes, and will have his coals driven free. A woman outworker will receive 8 cwt. of potatoes in addition to her cash wage. Milk will be charged at a rate not exceeding 1s. 4d. per gallon. Full wages will be paid for the first three days of sickness. The standard wage for men will for the current year be 33s. per week, and for women 20s. per week. (These wages are paid for each week in the year, including the long weeks in seed-time and harvest and the short weeks in winter.) Overtime will be worked when required by the employer, the rates being 1s. an hour for men, 8d. an hour for women, and time and a half for boys. If the hours fixed in the time-table are not convenient on account of the darkness of the morning or otherwise, arrangements may be made between the employers and the men for their alteration, provided the total number of hours per week is not exceeded.

It should be remembered that in addition to these working hours, which apply to almost all the staff on the farm except the cattleman and shepherd, the ploughman has also to spend some time on stable work, both on week days and Sundays, averaging about 7 hours a week all the year round, and that he has also to spend on the average about 20 minutes on ordinary working days and 10 minutes on Saturday half-holidays in bringing the horses home from the field, this time not being reckoned as working time. If these periods be added to the nominal "working hours," it may be reckoned that the average Scottish ploughman may have to spend away from his home on duty an average for the whole year of nearly 60 hours a week (50½ + 7 + 2). In winter his real working time averages about 56 hours a week (47 + 7 + 2), and

during harvest, in a week of continuous fine weather, it may rise to nearly 68 hours ($58\frac{1}{2}+7+2$), without any addition being made to his stipulated pay. On the other hand, his hours of actual work are liable to be curtailed by a spell of bad weather, more especially in the rainy west country and in the Highlands, without any loss in his earnings. If the present average weekly earnings of the Scottish ploughman be taken as 39s., and his nominal working hours average $50\frac{1}{2}$ a week, this gives the average earnings per hour of "work" as about $9\frac{1}{4}$d.; but if his hours of duty be reckoned as averaging 60 hours a week, his average earnings per hour of "duty" are about $7\frac{3}{4}$d.

Comparison with Conditions in England.—It is difficult to make an exact comparison between the conditions of farm labour in Scotland and in England, because the systems of working and of paying farm labour differ so greatly.

In Scotland, except in busy seasons, such as those of harvest, potato-planting and potato-lifting, very few temporary hands are employed, the work of the farm being for the most part, except in those busy seasons, carried on by the permanent staff. By far the greater part of the permanent male staff have animals in their charge, either as ploughmen, cattlemen or shepherds. A clear distinction is drawn between the married men and the single men, the married man, as a rule, being provided with a house and garden and allowances, which vary greatly from county to county, of such articles as potatoes, oatmeal, milk and coals. Almost the whole of the permanent staff is engaged either for the year or for the half-year, and during the whole period of a man's engagement, whatever be the hours worked, his cash wages do not vary, except that in some counties he is given an additional harvest fee of £1 or £2. Little payment is made for overtime, as the bargain covers the extra hours ordinarily worked in busy seasons. The man is not liable to dismissal during the period of his engagement, except for misconduct or breach of contract, and is, therefore, secure in his employment, and (if he is a married man) in the possession of his house for the year or six months for which he is engaged.

In the greater part of England a larger proportion of the male workers are temporarily employed, being dismissed in slack times and re-engaged in busy times. A larger proportion of the men in England than in Scotland are not in charge of animals, and have no stable or byre work to do after the field work is finished. A much smaller proportion of the men in England than in Scotland are provided with a house or allowances. Most of them are liable to dismissal on a week's notice, though, as a matter of fact, the majority of the regular farm hands are employed on the same farm year in and year out. They are liable, however, to a change of wages at the end of the term for which any agreement has been made. The position of the ordinary farm worker in England is, therefore, much less secure than that of his fellow in Scotland, whether as regards the period of employment, the rate of wages he can look forward to, or the possession of

his house. His weekly wages are also more liable to fluctuate according to the season and the amount of work required to be done on the farm.

In North Northumberland, according to an agreement which is to last till 11th May 1924, a man over twenty-one gets 32s. a week for 52½ hours in summer and a lesser number according to conditions in winter, with 10d. an hour for overtime on week days and 1s. an hour on Sundays, perquisites of house and garden, coal-leading and potatoes to be reckoned as payment for stable-time which is outside the ordinary hours. In Lancashire, under an agreement which is to last till 31st October, the standard wage for "special classes" for the usual working hours is 37s. 6d. a week in the northern area, 40s. in the eastern, and 35s. in the southern area, "other workers" getting 2s. 6d. a week less. In Cheshire, under an agreement, up to 31st October a man over twenty-one gets 32s. for a guaranteed week of 54 hours all the year round, with overtime at 9d. an hour; in Shropshire he gets 30s. for 53 hours guaranteed, and in Staffordshire 30s. for a guaranteed week of 54 hours. In Suffolk, according to an agreement, from 24th April until such time after the 30th September as one month's notice of revision is given, a man over twenty-one gets 25s. a week for 50 hours guaranteed, with overtime at 6d. per hour up to 54 hours, and 7½d. an hour after 54 hours, workers employed as horsemen and stockmen receiving an additional weekly sum of 5s., which makes a total for the horseman of 30s. a week, besides what he may earn for overtime. In Norfolk similar terms were agreed upon by the leaders of the respective sides after a strike. In a number of other agricultural counties in the centre and south of England, it is reported that the current wages of an ordinary adult male worker are from 25s. to 30s. for 50 hours work. It seems clear, therefore, that, except perhaps in some of the northern counties of England, the ordinary English farm worker not only enjoys less security of employment and of house-room, but is at present getting a lower average rate of earnings than at all events the married ploughman in Scotland, and that his actual weekly earnings are subject to greater variation from week to week. This will be understood more clearly if a closer comparison be made between the conditions at present existing under recent agreements in East Lothian and in East Anglia, both agricultural areas on the eastern seaboard.

In East Lothian the married ploughman is secure in his present employment and in the occupation of his house until the 28th May 1924. He will receive for every week until then, both in summer, in harvest and in winter, a cash wage of 33s. per week, and, in addition, will enjoy possession of his house and garden free of rent and rates, will have his coals driven free, and will receive 16 cwt. of potatoes free of payment. I have valued these allowances at 3s. a week, making his total average earnings 36s. a week, but they are really worth more, because in East Lothian the farm cottages are for the most part well built and commodious, and worth on

the average considerably more than the £5 a year I have reckoned for all Scotland. He will probably have little opportunity of adding to his earnings by working overtime, as his bargain for the year includes a full working week at seed-time and harvest. On the other hand, his earnings will not be reduced during the short days of winter or when farm work is slack owing to bad weather. In East Anglia the married ploughman is liable, on a week's notice, to dismissal, and to having to give up his house, for which he pays rent out of his cash wage. While his employment lasts, he is guaranteed a cash wage of 25s. a week for 50 hours' work, plus 5s. for attending to the horses, making 30s. in all, with few allowances, as the total earnings he can reckon on receiving week by week. He may in busy seasons receive payment for overtime for work done in excess of the 50 hours at the rate of 6d. per hour up to 54 hours, and 7½d. an hour after 54 hours; but he is not likely to earn much overtime payment except in harvest, because it will be to the interest of the farmer to get all the necessary work done within the minimum week of 50 hours, and to employ his workers in excess of that time as little as possible. As regards harvest, the custom is to pay for the harvest month a special rate in place of the ordinary wage rate. This year a dispute arose as to the harvest wages to be paid, but apparently on most farms an agreement was reached to pay £9 for the four weeks of harvest, in place of the 25s. a week ordinarily paid. This means an addition to the wage of all male workers of 80s., which is approximately equal to an average addition of 1s. 6d. per week for the whole year, making the average weekly earnings for the year of the ploughman in charge of horses about 31s. 6d. per week, besides what he can make by working overtime at other seasons of the year than harvest. It seems probable that the East Anglian ploughman will have on the whole somewhat fewer hours' work in the year, except in winter, than the East Lothian ploughman, because the East Lothian ploughman has contracted to work, if required, without extra payment, an average of 50½ hours per week for the whole year of his engagement, including 58½ hours in harvest, in addition to stable work, and it can rarely be necessary for the East Lothian farmer to employ him on overtime. For the man who is willing to take risks, and who would rather have short working hours than high earnings, the East Anglian system has some advantages; but for the man who values security of employment and of house-room for himself and his family, and who is prepared to bind himself to work longer hours, especially in busy seasons, for a higher rate of earnings, which will not vary from week to week, the system of engagement and of payment generally prevalent throughout Scotland is undoubtedly better.

The Higher Agricultural Education of the Future.

THE following interesting and important article by M. Em. Marchal, Member of the Royal Academy of Science, Belgium, and Professor of the State Institute of Agriculture, Gembloux, appears in the current issue of the "Review of the Science and Practice of Agriculture," published by the International Institute of Agriculture :—

Nearly every country in the world possesses at the present time a system of Higher Agricultural Education, representing in each case the most advanced stage of specialised instruction.

The actual role of this form of education as well as the question of organisation are the subjects of much controversy. Consequently, unless active measures are taken without delay, it appears that agricultural education in certain countries is faced with a serious crisis. It seems, therefore, desirable to determine clearly the ends which should be pursued in these higher studies, so that they may be brought into line with the present general requirements of agriculture.

To judge from prevalent opinion, particularly as shown in Belgium, two opposing points of view are expressed in the quarters most closely concerned. Higher agricultural education as at present organised has been accused of being too theoretical, so that the student is not kept sufficiently in touch with the realities of practical work. For example, it is stated that "the training provided at the agricultural colleges is much too scientific; it inspires the farmers' sons with too progressive scientific aspirations, and instead of preparing them for rural life tends rather to alienate them from work on the land."

For those who hold this opinion, the ideal function of the colleges is to give careful theoretical and practical instruction in the most approved cultural methods to students preferably themselves originating from the classes directly interested in the cultivation of the soil, and thus to train practical scientific agriculturists who will in the future, by their example and influence, stand out as leaders in the agricultural progress.

This desire to attract students from the country districts leads to the following characteristics in the arrangement of the programmes of study :—comparatively easy conditions of entry, limited duration of the course, a constant effort to give a practical bias to all the branches of instruction (including the basic sciences), the predominance of practical work on the farm and in the fields, over laboratory and lecture work.

The contrary theory is represented by those who consider that the function of higher agricultural education is not only to train students who will disseminate the knowledge of the progress already attained, but also, and more especially to prepare pioneers, research workers, and the moulders of future agricultural progress. With this object in view, the courses at the agricultural colleges, leaving aside all questions of professional training, should develop

still further the scientific side, and definitely take their place amongst the recognised higher University studies.

The writer, during a long professional career, has become convinced that agricultural education can best serve the special interests of agricultural science and the general interests of society by following the latter course.

The history of the great discoveries, which during the last fifty years have brought about the transformation of the art of cultivating the soil, hitherto in its rudimentary and empirical stage, into a complex and scientific industry, shows at each step the marks of the direct influence of pure science. Similarly the discoveries made by chemists and physiologists in their laboratories towards the end of the last century have resulted in the establishment of fundamental laws which determine animal and plant production, while purely abstract biological theories are being utilised at the present time as a basis for experimental work for still further enhancing the productivity of the soil. It is certain that the patient and laborious researches of Mendel, followed up and developed by a multitude of experimentalists, are the real source of the first definite stages of actual knowledge in the mysterious realm of heredity. Through the mutation theory of De Vries and the pure line selection theory of Johanssen, the Mendelian theory of heredity, still further confirmed as it has been by recent cytological research, is dominant in the field of genetics, that most fruitful branch of biology, without which animal and plant breeding would be the merest empiricism.

Viewed from another standpoint, it must also be acknowledged that the purely theoretical work of mycologists and entomologists, by the light that it has thrown on the evolution of parasites in all its most minute details, has led to the establishment of a scientific basis for the methods of control of plant diseases and pests. Lastly, the peculiarly delicate investigations of bacteriologists and biologists have already begun to throw a certain light on soil microbian life, and are opening up a prospect of interesting and profitable applications.

Everywhere and always pure science constitutes the active source from which, although often it may be by long and devious paths, true practical progress is surely derived. The first stages in this development are multiple. The theory itself is almost invariably the work of scientists which is in no way concerned with the utilitarian aspect of the research work on which they are engaged. It is the affair of less original minds, with a more practical bias, to grasp its possible bearing as regards practical application. Then comes the testing of the new theory and the stage of practical experiment, and finally, the general diffusion of the newly acquired knowledge amongst those to whom it is of importance.

However this may be, in any attempt to determine the part played by teaching institutions and research in furthering the great work of the scientific reform of agriculture, it must be admitted

that the aim should be pre-eminently to secure the necessary liaison between pure theoretical science and practice, and to select from among the original abstract theories of laboratory experts, the ideas that lend themselves to practical application, testing and adapting them to the actual requirements of agricultural technique, and finally and above all, to arrange for their general diffusion. The creative side of such institutions, although entailing much expenditure of time and energy, has been regarded, as a general rule, as of relatively minor importance.

The reason for this situation is to be found chiefly in the method of recruiting professors and research workers, as it is too often the case that less importance is given to high scientific qualifications than to technical skill on the "practical" side, without which, so it is said, any branch of science, however far reaching, often remains sterile in the sphere of application.

The result is that too often the duly qualified leaders of agricultural progress are not, owing to their lack of sufficient scientific training, fit to undertake original research even under favourable conditions. No other result could well be expected, seeing that the nursery where they were trained and whence they are often far too exclusively recruited, *i.e.*, the institution for Higher Agricultural Education, is often marred by the same fundamental defect.

On the contrary, the march of agricultural progress might be made far more rapid and sure, and much of the labour, expense and trouble of testing and trials might be avoided if our agricultural scientists were given a superior equipment of pure science, and could go direct to the original sources of the great discoveries for the maintenance of their activities.

Surveying the great problems in the light of their practical knowledge, and, directing from the outset the resulting theories towards practical applications, they would cause science to become in the applied sphere even more highly productive.

In the writer's opinion the most urgent need of to-day is rather for true scientists, competent to achieve success in original research, rather than for able technicians or merely popular lecturers. The responsibility for training such men lies with higher agricultural education, but if the work is to be adequately accomplished, higher agricultural education must develop and improve its methods and organisation, in at any rate many countries.

If the ideal scheme for training such highly qualified advisers on agricultural science and practice be considered, it will be seen that the course may be divided into two sections: a general scientific preparatory training and professional instruction proper. The first, owing to its specially comprehensive nature, is the outstanding characteristic of agricultural instruction; briefly, it includes the various branches of mathematical, physico-chemical, mineral and biological sciences.

In each of these fields it may be considered that the agricultural student should receive a training in no way inferior, either in

range or standard, to that required for a degree in pure science. In the writer's opinion the bias in the direction of "practical application," which is so often abused in the methods of scientific teaching preliminary to specialisation, constitutes a serious danger, as it tends, under the pretext, that they are abstract and devoid of any practical interest, to the sometimes almost complete neglect of entire sections of science, such as might ultimately be found to provide a source of important practical applications. Such a theory tends to encourage imperfectly qualified students with a limited horizon and sphere of interest, who will always be incapable of carrying out original research to advantage.

The University, with its great thinkers and vast and precious teaching resources, is undoubtedly the most favourable milieu for the purely scientific training of the agricultural scientists of the future.

It should not be difficult, by means of judicious interchanges in the programmes of the different faculties, to establish an ideal form of complete preliminary instruction, leading up to the special agricultural studies.

The agricultural scientist of the future in the next stages of his training course would thus be enabled to build up his purely professional instruction on the solid foundations of the sciences in general. It is at this stage only that the professional faculty or, in other words, the Higher Agricultural Institute enters into the field. Situated in the country and in rural surroundings, where at every point the instruction can be refreshed and invigorated by practical demonstration, the Institute with its experiment farm, its research station staffed with eminent scientists, should prove a focus of applied science in direct and constant touch with the great general intellectual centre provided by the University town from which, consequently, it should not be too far distant.

The organisation of the programmes of study and the method followed at this Institute will not be inspired by the essentially abstract conceptions of pure theory, but the far more tangible and living requirements of science applied to practice.

In order, however, to safeguard, from the point of view of its specialised character, the type of education which is required, various dangers must be avoided. In certain special schools, though classed as of the "Higher" rank, there is a tendency to make the professional instruction degenerate into a kind of technical initiation into the practice of such and such a branch of agricultural industry or speculation. Under the guise of exercises in the adaptation of theory to practice, the student is required to carry out processes and manual operations, which could be far better learnt after the completion of his studies, during the course of the stage which every student should pass through before starting on his professional career.

The subject of practical application in Higher professional instruction should take the form of training the student how to observe, measure and analyse, to complete his knowledge by

means of documentation, and to initiate him into experimental method and individual research. Such studies, it may be added, should tend to occupy an increasingly important position in the time table, as their teaching value is inestimable. It is pre-eminently in the study of practical applications and tutorial work that the professor will find his chief opportunity for acting as initiator and revealer; it is at the point of contact of theory with fact that he will best be able to show his mastery, and acquire that moral ascendancy that will make his pupil respect and honour in his person both science and professional ability. This is also the stage when he can most readily inspire the student with the love for research and the method to be pursued, by arousing his curiosity either in the progress and results of his special work or in other subjects equally capable of serving as a basis for original study. In short, the sphere of practical applications will give the professor the means for establishing on more solid bases than those of an examination a sound appreciation of the value and real knowledge of a student.

For the student himself, the practical exercises will provide the opportunity of obtaining the most solid and lasting form of knowledge, of developing his spirit of initiative and testing his capacities, and of gauging personally his degree of attainment. But, as already stated, the object of demonstration work and practical exercises must remain always at a high standard, as the period which the student can devote to his higher studies is too precious to be spent in carrying out work of a purely technical nature.

Another danger to be avoided in the higher agricultural course is, in the writer's opinion, the tendency towards an exaggerated specialisation. Agriculture viewed as a whole, undoubtedly occupies too vast a field to allow any individual to make a complete scientific study of all its branches. The agriculture of temperate and tropical countries respectively, forestry, horticulture, live stock, chemistry, technology and farm engineering, all form special branches of which an intensive study can be made with the object of training special classes of scientific agriculturists.

It is necessary, however, to safeguard the general agricultural training which an extreme specialisation would jeopardise, and to avoid turning out men with an incomplete equipment, who, although well trained in the minutest details of some particular branch, remain, owing to their insufficient knowledge of general methods and broad principles, incapable of seeing, understanding and adapting themselves to what takes place outside the narrow limits of their own accustomed sphere of activity.

A high level of preliminary scientific education, a far-reaching general professional training and a moderate degree of specialisation, such should, according to the views of the writer, be the qualifications which the agricultural scientist of to-morrow should be expected to supply.

It should be at once admitted that at present such a programme

is already, at any rate in its essential lines, being carried out in several countries. Such countries have realised that the day of a relatively easy victory and diffusion of knowledge is ended, and that for wresting from nature the secret of new wealth and for realising the imperious claims of impoverished humanity in this troubled post-war period for an increase in the productivity of the soil, an ever increasingly urgent appeal must be made to the aid of science as the only true generating force of progress.

Agricultural Credits Act, 1923.

THIS Act is designed to effect two distinct purposes:—

(1) To give what is commonly called "Long Term Credit" to the special class of farmers who bought their farms between April 1917 and June 1921;

(2) To supplement the working capital of farmers who find difficulty in obtaining Short Term Credit for seasonal and other outlays, the full return of which may be expected within a measureable period.

Under (1) the kind of case which the Act is meant to meet is that of a farmer who bought his farm within the period specified—probably not on his own initative—and, being unable to find the whole of the purchase price at the time, had to get some sort of accommodation for the balance. The Act enables him to convert his indebtedness into a Long Term Mortgage, repayable within a period of sixty years by equal yearly or half-yearly instalments of the principal sum advanced, together with interest on the amount outstanding, or by equal yearly or half-yearly payments of principal and interest combined, provided that the amount secured by the mortgage is not to exceed 75 per cent. of the value of the land mortgaged, as ascertained at the time of the mortgage. These mortgages may be arranged through approved Societies, who in turn derive their funds from the Public Works Loan Commissioners, or they may be negotiated directly, by the farmer applying for the advance, with the Public Works Loan Commissioners. The Treasury have prescribed 5½ per cent. as the rate of interest payable on the mortgages.

The main advantage to the farmer is not so much that he gets cheap money as that he knows exactly where he is with his liability to repayment, and that he can repay the debt by regular instalments spread over a very long period of years.

So far, a Company closely identified with the English Lands Improvement Company (1 Great George Street, Westminster, London, S.W.1.) has been recognised by the Treasury as an approved Society. This Society operates to a certain extent in Scotland, where Messrs Dundas & Wilson, C.S., 16 St Andrew Square, Edinburgh, act as agents for it. But no purely Scottish Society has been approved as yet in terms of the Act. In the meantime any Scottish farmer wishing to obtain the benefit of this part of the Act may apply to the Secretary, Public Works Loan Board, Old Jewry, London, E.C.2.

Section 2 of the Act is intended to encourage the formation of Agricultural Credit Societies, the general character of whose

functions is indicated in the Section as—"the making of advances to members of the Society repayable within a period not exceeding five years for agricultural purposes." These Credit Societies are to work on the co-operative credit of the members. Their formation is encouraged by the offer of £1 of capital advanced from Public Funds for every £1 of share capital. Each shareholder holding a £1 share is supposed to pay up at least 5s. thereof. The liability of each member is limited to the full value of the shares in the Society held by him.

It is to be expected that any such Societies will be formed mainly among small farmers and small holders or allotment holders who wish short time credit to meet such expenses as the purchase of seeds, fertilisers, feeding stuffs, the purchase of breeding and other live-stock, of machinery and implements, and the execution of such improvements as the erection of silos, barns, fencing, etc. The rate of interest payable by the Society on an advance from public funds obtained in Scotland through the Board of Agriculture for Scotland has been fixed by the Treasury at 5 per cent.

The Board hope to issue without delay a set of model rules for adoption by any such Societies.

Therms, Starch Equivalents and Fodder Units.

THE following notes on the different units adopted for indicating the relative values of feeding stuffs, and for measuring the food requirements of cattle, have been supplied by Mr Dan. W. Steuart, B.Sc.

Therms.—The unit adopted in Dr Armsby's American experiments (1912 to 1921) was the therm. A therm is defined as that amount of food which will supply 1000 Calories of nett energy. When a feeding stuff is burnt completely outside the body it gives rise to a definite amount of heat. For instance the fuel value of 1 lb. of the dry matter of red clover hay was 1980 Calories. When this was fed to a fattening bullock 1094 Calories were lost in the urine, in the combustible alimentary gases produced by fermentation, and in the indigestible portion in the fæces, leaving 886 Calories to the ox. Of this metabolisable energy 441 Calories are used in the internal work of mastication, digestion, etc., and appear as body heat (thermic energy), leaving of the original 1980 Calories only 445 Calories (nett energy) available for producing fattening increase. The nett energy value of red clover hay was thus 445 Calories per lb. of dry matter. Reckoning the hay with 85 per cent. of dry matter, then 100 lbs. had a nett energy value of 37,825 Calories, or 37·8 therms.

With the usual feeding stuffs the fuel values per lb. of dry matter are pretty much alike, 1950 to 2130 Calories; but the nett energy values are very different, 110 to 340 Calories for straws, 340 to 490 for hays, and 605 to 957 for concentrates, these being for wheat bran and maize meal respectively.

Starch Equivalents.—Dr Kellner's experiments (1892 to 1911)

gave rise to the starch equivalents. These are based on the following experimental results with fattening cattle:—

	Body Fat. lbs.	Relative value (Starch = 1)
1 lb. Digestible Carbohydrate and Fibre gave	·248	1·00
1 lb. Digestible Proteid gave .	·235	0·94
„ „ Fat in Cakes gave	·598	2·41
„ „ „ Grain gave	·526	2·12
„ „ „ Hay and Straw gave . . .	·474	1·91

If we calculate the starch equivalent from the digestible constituents of a feeding stuff with the help of these relative values, the result is usually somewhat high compared with the results of actual feeding experiments. So a correction has to be made for the "wertigkeit" or availability. Valuing pure digestible nutrients at their full value = 100, then those in barley have a value of 99, in ground nut cake 98, in clover hay 70 and so on.

The calculation of the starch equivalent of barley per 100 lbs. would be:—

Digestible Proteid	$6{\cdot}5\% \times 0{\cdot}94 =$	6·11
„ Fat	$1{\cdot}7\% \times 2{\cdot}12 =$	3·60
„ Carbohydrates and fibre .	$63{\cdot}1\% \times 1{\cdot}00 =$	63·10
		72·81

$$\frac{72{\cdot}81 \times 99}{100} = 72{\cdot}0$$

So 100 lbs. of barley fed to a fattening bullock (in a suitable ration) would give the same fattening increase as would 72 lbs. of starch; or barley contains 72·0 per cent. of starch equivalent.

Since 1 lb. of digestible starch gives rise to ·248 lbs. of body fat, and ·248 lbs. of body fat has a fuel value of 1068 Calories, so 1 lb. of starch equivalent is equal to 1068 Calories of nett energy or 1·068 therms.

The Fodder Unit.—The fodder unit (*vide* this *Journal*, Oct. 1920, 433–8) originated in the Scandinavian countries (*vide* this *Journal*, Oct. 1922, 410). Its use seems likely to become general as the exceedingly great value of pure milk as a protective food is fully realised and milk cows become the chief live-stock in every civilised country.

I. For Fattening Cattle.—When used as a measure of the ration of fattening cattle a fodder unit is equal to from ·68 to ·72 lbs. of starch equivalent, ·7 lbs. on the average. It contains about 748 Calories of nett energy and so is roughly equal to ·75 therms.

II. For Milk Production.—When a cow is allowed daily 1 fodder unit per each 150 lbs. of live-weight for maintenance, then it is shown by the statistics of the Swedish control unions

that each unit in the production part of the ration will produce 3 lbs. of average milk:—

	Malmohus.		Östergotlands.
	1906 7	1914–15	1920–21
Number of Cows	33,500	41,597	18,794
Yield of Milk per Cow—lbs.	7,446	8,145	6,769
Fat in Milk—per cent.	3·23	3·24	3·50
Estimated weight per Cow—lbs.	1,155	1,155	1,100
Fodder Units supplied per Cow	5,300	5,500	4,928
Units required for Maintenance	2,810	2,810	2,677
Units left for Production	2,490	2,690	2,261
Milk produced per Unit—lbs.	3·0	3·0	3·0

As 3 lbs. of such milk have a fuel value of 952 Calories, so 1 fodder unit for milk production contains 952 Calories of nett energy or 27 per cent. more nett energy than if it were used for fattening purposes. When proteid is used by a fattening animal to produce fat in the body, a combustible nitrogenous portion (urea or hippuric acid, etc.) is lost in the urine with a corresponding loss of energy. When proteid is used by a growing animal to produce the proteids of flesh, or by a cow to produce the proteids of milk, the loss of energy will be correspondingly less. So when we calculate the milk producing value of a food, which is done in the same way as we calculate the starch equivalent, we allow each lb. of digestible proteid a value of 1·43. This figure is obtained when we divide the fuel value of proteid, 2590 Calories per lb., by the fuel value of carbohydrate, 1815 Calories per lb. A fodder unit is defined as that weight of a food which in feeding cows is equivalent to 1 lb. of barley, 1·1 lb. of the dry matter of roots, or which contains ·75 lbs. of milk producing value. So 1 lb. of milk producing value contains 1270 Calories of nett energy. The milk producing value of barley, availability 99 per cent., and of green fodder silage, availability 68·4 per cent., would be calculated as follows:—

	Barley.	*Silage.*
Digestible proteid	$6{\cdot}5 \times 1{\cdot}43 = 9{\cdot}3$	$2{\cdot}10 \times 1{\cdot}43 = 3{\cdot}00$
„ fat	$1{\cdot}7 \times 2{\cdot}12 = 3{\cdot}6$	$0{\cdot}99 \times 1{\cdot}91 = 1{\cdot}89$
„ carbohydrates and fibre	$63{\cdot}1 \times 1{\cdot}00 = 63{\cdot}1$	$12{\cdot}21 \times 1{\cdot}00 = 12{\cdot}21$
	$76{\cdot}0$	$17{\cdot}10$
Milk producing value per 100 lbs.	$\frac{76{\cdot}0 \times 99}{100} = 75{\cdot}2$	$\frac{17{\cdot}1 \times 68{\cdot}4}{100} = 11{\cdot}7$
Fodder units per 100 lbs.	$75{\cdot}2 : 0{\cdot}75 = 100{\cdot}3$	$11{\cdot}7 : 0{\cdot}75 = 15{\cdot}6$

The accompanying table shows the relation between the nett energy values, starch equivalents and fodder units in various

feeding stuffs. [There are as yet no reliable Swedish data for calculating the production values of straws.] To summarise:—

With fattening cattle—

1 therm . . .	= 1000	Calories nett energy	
1 lb. starch equivalent .	= 1068	"	"
1 fodder unit (lb.) averages	= 748	"	"

With milk production—

1 lb. milk producing value	= 1270	"	"
1 fodder unit (lb.) .	= 952	"	"

In order that a feeding stuff may exercise its maximum effect it must be fed as an ingredient of a sufficient and well-balanced ration. The necessary amount of digestible proteid must be supplied; the mineral requirements of the animal must be met; such vitamines as may be essential must be supplied. Moreover, the dietetic effect of the ration must be considered; it must neither be too laxative nor too constipating.

	Dry Matter per cent.	Crude Nutrients per cent.					Digestible Proteid per cent.	Availability. Full Value = 100.	Fodder Value per 100 lbs.				
		Protein.	Fat.	Carbohydrates.	Fibre.	Ash.			Starch Value. Lbs.	Nett Energy for Fattening. Therms.	Milk Producing Value. Lbs.	Nett Energy for Milk Production. Therms.	Fodder Units. Lbs.
Barley . . .	85·5	10·0	1·9	67·1	4·0	2·5	6·5	99·0	72·0	76·9	75·2	95·5	100·3
Oats . . .	86·2	10·9	4·8	58·1	9 3	3·1	7·7	95·0	59·6	63·7	63·2	80·3	84·3
Peas . . .	85·6	23·5	1·4	52·5	5·4	2·8	17·2	98·0	68·0	72 6	76·2	96·8	101·6
Ground Nut Cake	90·0	45·5	8·0	25·2	4·8	6·5	39·6	98·0	74·9	80·0	94·0	119·4	125·3
Soya Bean Cake .	88 0	43·3	5·5	28·7	5·0	5·5	38·7	96·0	75·0	80·1	92 8	117·9	123·7
Coconut Cake	89·5	21·4	8·5	38·7	14·7	6·2	18·6	100·0	78·9	84·3	88·1	111·9	117·4
Mangels . .	12·0	1 1	0 1	8·8	1·0	1·0	0·4	87·0	8·2	8·8	8·4	10·7	11·2
Turnips . .	8·8	1·0	0·1	5·9	1·1	0·8	0·4	87 0	5·8	6·2	6·0	7·6	8·0
Silage . .	28 5	3·7	1·5	12·3	8·6	2·4	2·1	68 4	11·0	11·7	11·7	14·9	15 6
Timothy Hay .	85·0	6·5	2·0	42·2	29·5	4·8	3 0	63·0	29·1	31·1	30·0	38·1	40·0
Grass-clover Hay	83·0	9·5	2·0	39·5	26·3	5 7	4·2	67·0	29·2	31·2	30·6	38·9	40·8
Clover Hay .	83·5	13·5	2·9	37·1	24·0	6·0	5·5	70·0	32·0	34 2	33·9	43·1	45·2
Oat Straw . .	85·0	3 9	1·9	38·0	35·4	5·8	1·0	48 0	18·3	19·5	18·8	23·9	25·1
Barley Straw .	85·0	4·3	1·6	36·8	37·2	5·1	0·9	49·0	20·4	21·8	20·5	26·0	27·3

To take one example of the experimental results which are met in this connection—when cows yielding 30 lbs. of milk daily get 85 to 100 lbs. of roots, the roots do not exercise their full effect, and 1·1 lb. of the dry matter in the roots would not entirely replace 1·2 lb. of ground oats. The optimum supply of roots is 55 to 75 lbs., increasing, however, with higher milk yields. In this case 1·1 lb. of the dry matter of the roots will replace 1·2 lb. of oats without the milk yield suffering. Where a unit of roots can be grown cheaper than a unit of oats, it would still pay to feed rather more roots than the optimum indicated.

Another point arises in this connection. Based on Armsby's

results, the nett energy value of maize meal for different animals can be estimated in therms per 100 lbs.:—

For fattening cattle	85·5
„ feeding horses	112·8
„ „ pigs	118·8

So the nett energy value of one food is not the same for different animals. Hence it is necessary to construct tables showing the relative values of foods for horses, cows and pigs separately (*vide* this *Journal*, April 1921, 155). Fortunately the *relative* values of feeding stuffs for the various animals are not very different.

REFERENCES

From HANSSON, *Kungl. Landbruks-Akad. Hand. Tid.* of 28th January 1923.

Cf. LEROY, *Bull. soc. hyg. aliment.*, *10*, 415-33, 1922.

See also 1922 edition of Professor HANSSON'S *Husdjurens Utfodring*.

Foxes and Methods of Destruction.

THE following notes on foxes and methods of destroying them have been supplied by Mr T. M. Tod, West Brackley, Kinross, who has had long practical experience in dealing with this pest.

The depredations committed by the fox during the lambing season are well known, and every flockmaster who is troubled by this animal's ravages is anxious to adopt every means of counteracting them. It is by no means easy to catch him, however, as no animal can detect danger more quickly, and although there are foxes about, it does not follow that they will play havoc in the lambing field. The writer has known season succeed season in a non-hunting county where foxes have passed through the fold in the course of their nightly wanderings and have left the lambs alone to continue their search for prey farther afield. But it is comparatively simple to tell in the morning whether the enclosure has been "visited," as the sheep dog can usually sent the fox hours after his visit. Once a fox has drawn blood, however, he will return night after night, maiming perhaps three or four lambs in addition to carrying one home with him. Of the methods of destruction open to the flockmaster, the two following are the most effective:—

Steel Traps.—This method is undoubtedly the most satisfactory. Procure a dead hen in a state of decomposition and bury it a few inches deep, leaving some feathers sticking up above ground. Then place six strong traps chained to stakes driven two feet into the ground at selected points round the grave. Great care must be taken to place the traps in suitable spots, say a few yards from the corner of a low dyke, as the fox always chooses the easiest means of access to the booty; and they should be so placed that stock cannot have access to them. The fox is unlikely to be

caught on the first morning after setting the traps, but if he chances to pass that way frequently he will in the end be enticed to the snare by the stench. When the fox is trapped, he should be shot from a distance as it happens not infrequently when one approaches that he will make a supreme effort to escape, even at the expense of leaving a foot behind. Traps should be examined daily as a rabbit or other animal caught in them may scare the fox away for several days.

Shooting.—The other way of putting an end to the fox's career should not be undertaken by anyone except he is possessed of an iron constitution and can sit motionless for hours behind a dyke or other shelter. Unless the moon is favourable, however, the watch is useless. Due attention must be paid also to the direction of the wind as the fox will scent danger long before he is within gunshot. In a district where foxes are fairly numerous, the writer has been successful only once in shooting a fox as he was about to enter the lambing field, and that was at 3 a.m. after a four hours vigil on a clear cold night.

Some flockmasters adopt the precaution of keeping lighted lamps in the field, but this is an expensive method and may lead to the lambs being stolen if near a highway. It cannot be said that the method is infallible, however, as if the fox has once had a taste of lamb food a stationary light will not effectively prevent his return. The noise of a miniature windmill is more efficacious, but on a still night this method is of no avail. It is good policy, however, before the lambing period commences to pay a visit to the fox's haunt and set traps around his lair as a precaution against future possibilities. If there is a covering of snow on the ground, the lair may be located easily by the footprints. When carrying provender, however, the fox does not usually go direct home if he has time to spare, but will take a circuitous route perhaps a mile longer and may even pass the entrance to his den, so as to divert suspicion, before turning back. A disused rabbit burrow which he has enlarged or a hole under a large stone among rocks are favourite haunts of the fox. He usually starts his nightly pilgrimage an hour or so after midnight and returns just when dawn is breaking, so that in the course of his wanderings he must traverse considerable distances, but not without halting every now and then to listen, and to sniff the breeze.

Agricultural Holdings (Scotland) Act, 1923.

THIS Act, which received Royal Assent on 7th June last, and came into force on 7th July, effected a much-needed consolidation of the law. The Agricultural Holdings (Scotland) Act, 1908, which now disappears from the Statute Book, was itself a consolidating Act, under which various Acts passed between 1883 and 1906 were codified. Apart from the short amending Act of 1910, the Act of 1908 remained unaltered until 1920, when extensive

alterations and additions were made by Part II. of the Agriculture Act. As this Act covered the whole of Great Britain, its application to Scotland required an elaborate section extending to over three pages of print, and dealing with many material as well as formal points. Further amendments were introduced by the Agriculture (Amendment) Act, 1921, and by sections 5 and 6 of the Corn Production Acts (Repeal) Act of the same year. The extant and relevant provisions of all these Acts, together with the operative section of the Agricultural Land Sales (Restriction of Notices to Quit) Act, 1919, have now been embodied in a comprehensive Act relating to Scotland alone, and the Acts themselves, or parts of Acts, have in consequence been repealed.

The sections of the new Act are arranged under the following headings :—

Compensation for Improvements on Holdings (Sections 1 to 8). Compensation in respect of increased or diminished Value of Holdings (Sections 9 and 10). Compensation for Damage by Game (Section 11). Compensation for Disturbance (Sections 12 to 14). Arbitration (Sections 15 to 20). Charge on Holding for Compensation (Sections 21 to 24). Removing for Non-payment of Rent (Section 25). Notice of Termination of Tenancy (Section 26). Restriction of Notices to Quit in case of Sale (Section 27). Bequest of Lease (Section 28). Fixtures and Buildings (Section 29). Miscellaneous Rights of Landlord and Tenant (Sections 30 to 37). Persons under Disability (Sections 38 and 39). Crown Lands (Section 40). Ecclesiastical and Charity Lands (Section 41). Special Provisions as to Market Gardens (Section 42). General (Sections 43 to 52).

Of the whole Act about half is taken from the Act of 1908, and half from the subsequent Acts. The chief provisions taken from the Act of 1920 are in Sections 5, 9, 10, 12, 14, 15, 17, 18, 19, 31, 33, 36 and 37, and the definition of "Rules of good Husbandry" in Section 49. Special attention may be drawn to Sections 13 and 30. The former is practically equivalent in its terms to Section 10 of the Act of 1908, but deals only with grass parks or other land that is excluded from the scope of Section 12 of the new Act (corresponding to Section 10 of the Act of 1920). Section 30 is (with one alteration) identical with Section 23 of the Agricultural Holdings Act, 1908, which applied to England and Wales. It was applied to Scotland by the Act of 1920, with the alteration already mentioned, and is now embodied in the new Act.

The First Schedule to the Act of 1908 was modified in 1920 by the addition of two items to Part I. and by an addition to what is now item 28 in Part III.; a slight alteration was also made in Rule 10 of the Second Schedule. These changes are now embodied in the Schedules.

The new Act should be studied by all concerned in the management of land or in agricultural arbitrations, etc. Copies may be obtained from H.M. Stationery Office, 120 George Street, Edinburgh, price 9d. or by post 10d.

Three books explanatory of the Act have been published :—

(1) By Sir Isaac Connell, S.S.C., published by Messrs. Wm. Hodge & Co., price £1 ; (2) by Mr. J. S. C. Reid, B.A., LL.B. Cantab., published by Messrs Blackwood & Sons, price 12s. 6d. ; (3) by Mr G. M. Dobie, M.A., LL.B., published by Messrs Green & Sons, price 7s. 6d.

In view of the complexity of the Act and the large number of legal decisions bearing on its provisions, these volumes will no doubt prove most useful to all concerned.

A similar consolidating Act for England and Wales became law at the same time as the Scottish Act.

A State Experimental Dairy in Denmark.

ON July 27th a State Experimental Dairy was opened at Hillerd, near Copenhagen. The building of this institution, which has long been contemplated, was commenced only a year ago, and the laboratories are not yet completed. The cost of building and equipment has been met chiefly by a Government grant of 532,000 kroner (nearly £21,000 at the present rate of exchange), and the surplus required over that amount, say another £10,000, will be contributed by an association which includes all the co-operative dairies in the country. Of such co-operative dairies there are 1465 in Denmark.

The institution is planned on Danish pattern throughout, on the basis of that country's wide practical experience of dairying. The machinery is exclusively Danish, and the director claims that it is the best dairy machinery in the world.

The experimental dairy will use 15,000 lbs. of milk daily, supplied by 1000 cows. Of this amount 40 per cent. will go back to the producers as skimmed milk. The products, cream, butter and cheese, will be disposed of under a special mark in Copenhagen.

It is expected that by means of this experimental dairy the standard of dairy farming in all its branches will be raised still higher than it is now in this progressive agricultural country. For many years now the Government of Denmark has recognised that the prosperity of the country is bound up with the success of its dairy farming, and it has been a pioneer in practical agricultural education. This has enabled the advances in agricultural science to be put into practice in Denmark in many cases years before they have been applied elsewhere. The prosperous and happy state of Denmark at the present day as compared with half a century ago, justifies this policy of the development and dissemination of scientific knowledge of the principles of farming. This new venture is merely a development of that policy, and it is almost certainly assured of a success that will more than repay the expenditure.

THE following information has been extracted from reports received from the Department of Overseas Trade:—

Overseas Trade. *Potatoes in France and Belgium.*—The area planted with potatoes in Belgium this year is 151,936 hectares as compared with 178,000 hectares in 1922.

The potato crop in the west of France is likely to prove deficient. In the north of Brittany the potatoes are reported to be diseased, and in the Loire-Inferieur the dry period has checked their growth, and importation may prove to be necessary. About 5000 tons of potatoes were imported at Nantes from Northern Ireland during the early part of 1923 to meet last season's shortage.

Co-operative Poultry Slaughteries.—At a recent meeting of poultry farmers in Denmark it was resolved to establish Co-operative Poultry Slaughteries, with the object of organising the trade in Danish slaughtered poultry, but chiefly to avoid the "middleman," and thus secure higher prices for the producers. The slaughteries of which it is proposed to establish four in different parts of the country will be managed on purely co-operative lines. Each slaughtery will probably employ from forty to fifty hands, exclusive of office staff, and each will be able to deal with about 3,000 head of poultry per day. A veterinary surgeon will be employed to examine the birds as to their fitness. Besides supplying the home markets it is hoped as a result of the establishment of these slaughteries to work up an export trade for Danish poultry.

Exportation of Milk and Dairy Products from Holland and Sweden in 1922.—According to official reports the number of co-operative factories in Holland in 1922 amounted to 631 and of the non-co-operative factories to 308. The figures for 1921 were respectively 640 and 311.

The following table gives particulars of the export from Holland in 1922 of certain milk products:—

PRODUCT.	Total Exports.		Exported to U. K.	
	1922.	1921.	1922.	1921.
	Kg.	Kg.	Kg.	Kg.
Condensed Whole Milk	19,835,000	24,831,000	9,698,000	Not quoted
Condensed Skimmed Milk	66,508,000	50,829,650	61,187,000	"
Milk Powder	4,802,000	5,773,718	...	"
Cream	2,066,000	1,521,000	...	"
Butter	23,125,000	19,035,900	3,974,000	3,252,000
Cheese	65,193,000	52,290,000	9,250,000	6,933,000

In Sweden the production of butter classified as "Rune mark quality" (Best grade, fit for export) amounted in 1922 to 20,607,464 kilogs. as against 18,089,460 kilogs. in 1921. Exports, however, amounted to only 1,380,238 kilogs., of which 931,168 kilogs. went to Great Britain, the remainder being disposed of in

Denmark and Norway. Some increase in the amount exported was noticeable towards the end of the year.

Agricultural Conditions.

THE weather during June was rather cold and in some districts night frosts were frequent. The conditions improved during the last week of the month and crops and stock made better progress. July was favourable generally for agriculture and crops progressed very satisfactorily. The first half of the month was warm and dry in most parts, but thereafter the temperature was somewhat lower and there was a moderate rainfall. The month of August was to a great extent unsettled and in many districts the temperature was unusually low for this period of the year. Rain was frequent, and in some parts heavy, and the amount of sunshine was below the normal. Grain crops were slow in ripening and harvest promised to be later than usual in most parts. In a few districts the hay harvest had not been fully secured at the end of August. Potatoes and turnips were improved by the rains during August, but owing to the lack of heat and sunshine they are still somewhat backward in growth in many districts.

The cutting of wheat was in progress at the end of August in Perth, South-West Forfar, Fife, the Lothians and Stirling, while in Moray, North-East Forfar, Berwick, Roxburgh, Renfrew, Lanark and Ayr harvest was about to begin. The crop was a good one on the whole; from South-West Forfar and North-East Fife it was reported that wheat was the best of the cereal crops.

The barley crop was generally healthy and vigorous, but, as in the case of wheat, ripening was abnormally slow. In North-East Forfar, however, the plant was thin in many cases; in East and North Perth and in North-East Fife the crop was especially unsatisfactory on light land. Harvest had commenced at the end of August in some of the earlier districts but cutting was not general until about the third week of September. Average yields, or slightly over, are estimated in Banff, East Aberdeen, North-East Forfar, South-West Perth, Roxburgh, Stirling, North Argyll and Kintyre. Elsewhere, however, the yield is more or less below the normal, the deficiency in South-East Perth and South-West Forfar being estimated at 15 per cent. Bere has been an average crop generally, except in Aberdeen.

The reports on oats were very varied and were, on the whole, much less favourable than in the case of wheat and barley. Satisfactory crops have been reported in some of the northern and western districts, but, taking the country as a whole, the yield is expected to be rather below the normal. Yields varying from 10 to 15 per cent. below the average are estimated in North-East Aberdeen, North and East Perth, South-East Fife, Berwick, Orkney and South Ayr; in South-West Forfar and South-West Fife the estimated yield is from 15 to 20 per cent. below the normal, while in South-East Perth the deficiency is estimated to be 40 per cent. The crop has been generally healthy but, as in the case of the other cereals, ripening has been very slow. In some parts, more especially

in the western counties, many fields were still green at the end of August. Harvest was in progress at the end of August in some of the earlier districts, but cutting was not general until the middle of September or later.

Beans were generally healthy but the yield on the whole will probably prove to be rather below the average.

Potatoes are a fairly satisfactory crop in the majority of the districts. In several of the more important potato-growing districts, however, the crop is more or less below the usual standard and consequently the yield for the whole country will probably be rather below the average. In North-West Aberdeen, Central Perth, North-East Fife, Berwick and South-East Lanark the yield is estimated to be from 10 to 15 per cent. below the average, while in Lewis the estimated yield is lower by 25 per cent. Reports of disease to a greater or less extent have been received from Ross, Inverness, Uist, Islay, Renfrew, Ayr and Wigtown; in Stirling some areas are affected by blight while in Lewis serious damage is reported owing to the same cause.

Turnips and swedes have made good progress and in the great majority of the districts an average yield or over is estimated. The least satisfactory reports are those from North-East Fife, Caithness and North Ayr where the yield is estimated to be about 10 per cent. below the normal. "Finger-and-toe" and canker are rather prevalent in some of the northern and western districts, while in the reports from Moray, North-West Aberdeen, Dumfries, Kirkcudbright and Wigtown it is stated that many early sown crops have gone to seed. Mangolds are generally healthy but growth has been exceptionally slow. In Berwick an abnormal number of the plants have "bolted," and in this district the yield is estimated to be 15 per cent. below the average. In Lanark, however, the estimated yield is above the normal by 15 per cent. and in Kintyre by 10 per cent., while in several other districts a full average is expected.

Strawberries were a full crop in Banff, Central and North-East Aberdeen, Central Perth, Central Argyll and Dumfries, but the yield was disappointing in South-East Perth and Inverness and was rather below the average in Lanark. Except in Banff and North-East Aberdeen the yield of raspberries was everywhere below the normal. In North and East Perth strawberries yielded 20 cwt. per acre and raspberries from 30 to 40 cwt. In Dumfries currants and gooseberries were an average yield, while in South-East Perth red currants proved a satisfactory crop; elsewhere, however, the yield varied from bad to indifferent. Plums were practically a failure in South-East Perth and Central Argyll, while in Dumfries the yield was considerably below the normal. Apples and pears have also been indifferent crops in Dumfries while in South-East Perth pears are scarce and apples are only about a half crop. Fruit of all kinds was below the average, both in quality and yield, in North-East Fife; considerable damage was caused owing to high winds during August.

The rainfall during August benefited pastures which in most cases kept up well. Grazing cattle have generally done well, but

in Ayr, Dumfries, Kirkcudbright and Wigtown their progress was more or less affected owing to the wet weather in August. Dairy cows are reported to be in a healthy condition in most districts. Sheep on arable farms have made fair progress but in North Ayr, owing to the unfavourable weather, they have not thriven so well as usual. Hill sheep have generally done well although in some cases they are not so well grown as usual. Lambs were generally in fair condition when they were sent to the sales.

Bees did fairly well in Moray, Banff, North-East and Central Aberdeen, Kincardine, North-East Forfar and North Argyll. The yield of honey has been below the normal in most districts, but an average yield is estimated in Central Aberdeen, Kincardine and North-East Forfar. Disease has been prevalent in Central Perth, but elsewhere the stocks are generally healthy.

The supply of regular labour is generally adequate for requirements, but casual labour for harvest work is rather short in Wigtown and Skye.

Conference of Scottish Agricultural Research Workers.

THE scheme of organisation of agricultural research in Scotland, as planned by the Board of Agriculture for Scotland in consultation with the Development Commission, is now in operation, at all events in its main lines. In order to co-ordinate the work and to secure co-operation where necessary, the Board has formed an Advisory Committee of representatives of the various Research Stations and Colleges, and regular meetings of this committee will be held to discuss points of common interest and to arrange for team work. It is also intended to have at stated intervals meetings of those engaged in research work and of members of the staffs of the three Agricultural Colleges. At these meetings papers will be read descriptive of research work in progress or just completed, and suggestions will be discussed for passing on useful information to the agricultural community.

The first conference was held at Aberdeen on 24th and 25th July last, and was attended by about a hundred representatives of the Research Stations, the Universities and Agricultural Colleges, and the Staff of the Board.

By the courtesy of the University authorities the meetings were held in Marischal College. Sir Robert Greig presided at the first sederunt and Mr James Wood at the second. The afternoons were spent in visits to the Rowett Research Institute, Essiehillock Croft, and Craibstone Experimental Farm and School.

The Conference was thoroughly successful and much credit is due to Mr D. B. Gunn, secretary of the Rowett Institute, in whose capable hands the local arrangements were left.

A short summary of the papers read is appended :—

Dr Orr, Director, Rowett Research Institute, referred to the origin and objects of the Institute, and the work which had already been done or was contemplated. An article by Dr Orr on this subject appeared in the issue of *The Scottish Journal of Agriculture* for January, 1923.

Factors affecting Calcium and Phosporous Metabolism. W. Godden, Rowett Research Institute.—Investigations conducted in the biochemical department of the Rowett Research Institute were designed to determine the influence of (*a*) certain oils; (*b*) the alteration in the balance of the various mineral constituents of the ration, on the assimilation and retention of calcium and phosphorus by the young growing pig. The results of three series of metabolic experiments were quoted and outlined in graphs. They were intended to determine the relative influence of cod-liver oil, linseed oil and olive oil in the absorption and retention of calcium and phosphorus. It was thought that the experiments would show the influence of oil *per se*, and also whether the vitamin rich cod-liver oil had a specific action. A detailed account of the results of these experiments is the subject of a paper (by Husband, Godden and Richards), which is submitted for publication in *The Biochemical Journal.*

Effect of Deficiency of Iron. Dr M'Gowan, Rowett Research Institute.—Iron deficiency had been investigated in the case of the diet of suckling pigs. The symptoms observed begin at about three weeks of age. They consist of a fat, "stocky" appearance, pallor of skin, laboured respiration—"thumps"—liability to sudden death, cough, diarrhœa occasionally, temperature normal to subnormal, occasionally blueness of tips of ears and along back. Examination at this stage shows hæmoglobin percentage to be about twenty, great dilatation of the heart, effusion of fluid into pericardial sac, pleural and peritonial cavities and œdema of lungs. Liver shows marked fatty change in the centre of the lobules, and fatty change is also present in the kidneys and myocardium. Pigs, surviving the acute stages just described, cease to grow, become very hairy, with dirty skin, often cinnamon coloured, and have a persistent chronic cough. Examination of such animals shows fibrous adhesions in pericardial, pleural and peritonial cavities. The lungs are the seat of a chronic pneumonia. The liver, in addition to adhesions, shows the "fairy ring" appearance. The disease occurs especially when the nursing sows in close confinement are fed on a diet poor in iron, but can also occur under similar circumstances when they are on ordinary diet. It can be prevented by the administration of iron in excess, which in ordinary circumstances can be done by mixing ferric oxide liberally with the food of the sow. This may act by increasing the amount of iron in the milk, which is notoriously a food poor in iron. It is more likely, however, that the beneficial results obtained are due to the young pigs nibbling and chewing the iron-rich food thus supplied. A cure, so far as this is possible, of those affected with the disease can also be accomplished in the same way. The iron deficiency in these cases is a relative one, and the occurrence of the disease depends very markedly on the rate of growth of the animal. Thus the weaklings of the litter do not develop it, its incidence falling on the fast growing, apparently more healthy members.

From its wide occurrence and the direct and indirect losses attributable to it, the disease is in all probability the most important in the pig industry. It would seem that under the usual methods of pig culture, the suckling pig is always hovering about the danger line, and that, while in many cases the disease may not obtrude itself by causing deaths in the suckling age, its results can be traced throughout the subsequent life of the pigs in the form of chronic cough, general malnutrition in varying degrees, etc.

The possible relation of the disease to cotton-seed poisoning in pigs in America and to the dropsical form of beri-beri in human beings was discussed, as was also its bearing on conditions of illness in children reared for the most part on milk or artificial foods.

Determination of the Energy Requirements of the Ruminant. Dr H. E. Magee, Rowett Research Institute.—The theory of Indirect Calorimetry was briefly explained, and some of the common methods in use having been compared, the unique advantages of the "Douglas bag" method for use in Basal Metabolism experiments on animals were described. The difference between the expired air of the ruminant as compared with omnivora was pointed out, and it was shown that by analysis one could differentiate the gases due to fermentation of food from those due to tissue metabolism. After

discussing the Basal Metabolic Rate (B.M.R.), as also the factors that influence it, a brief summary of some of his results was given :—

1. Standing animals show a 12 per cent. increase in metabolism as compared with the same animals lying. Man shows a similar increment, viz., 13 per cent.

2. Variations in external temperature.—Between 55° and 70° F., metabolism is at a minimum and the metabolic curve is practically a straight line; from 55° to 40° F. there is a slight progressive increase, and from 70° to 98° F. a marked progressive increase in the rate. The "cold" increase is due to the onset of chemical regulation, *i.e.*, more food is being used to increase the oxidative processes. The "warm" increase is due to the efforts of the animal to get rid of surplus heat.

3. Pregnancy.—It is not until the thirteenth week or until approximately three-fifths of the period in the goat has passed that a definite increase in the B.M.R. is obtained. This increase continues up to parturition when it falls, and is due to

(*a*) The additional mass of living protoplasm ; and

(*b*) A stimulation of the maternal cells by the embryo.

4. Influence of the foodstuffs.—This work is not yet completed. The increase in metabolism following a mixed ration presents a double-peaked curve, with apices at ½ hour and 2½ hours after eating. The exact significance of these is not at present fully understood. This increase may be due to one or both of two factors, viz., the work of digestion and the specific dynamic action of the food. There does not seem to be any doubt but that the latter factor is responsible for most, if not for all of the increment.

5. The methane production appears to be a very complex subject. It seems to vary with (*a*) the nature of the food eaten a short time previously ; (*b*) the nature of the diet for perhaps some considerable time previously ; and (*c*) the feeding time.

Mr Crichton in his paper on *Some Practical Aspects of the Mineral Requirements of Farm Animals* showed how the research work being carried on at the Rowett Institute affected the practical stockfeeder.

Rations of cereal products were very liable to be deficient in minerals, more especially in those required in greatest quantity. The mineral composition of the animal body serves as a guide to the absolute amounts required of these various minerals. Feeding experiments carried out at the Institute had shown that rickets in the pig was due to a deficiency of one or more of these essential minerals, and that the disease was prevented by the addition of a lime-rich mixture of salts. The feeding to brood sows of a ration deficient in iron had disastrous effects on the subsequent litters of these animals. Experiments had also been carried out in connection with the mineral requirements of the dairy cow, and it was probable that a ration properly balanced in all the ingredients, including the essential minerals, might tend to decrease the great susceptibility of heavy milking cows to disease by decreasing the drain from their tissues of supplies of mineral matter for their milk. Instances were cited of nutritional disease being due directly to the lack of one essential mineral, such as the lack of iodine in the case of hairless pigs and shell-less eggs.

The study of mineral metabolism, though still in its infancy, was a long standing one, and the stockfeeder for centuries back had often used mineral materials for his stock with beneficial results, believing that they acted as tonics, etc., rather than that they supplied actual deficiencies. In compounding rations for farm stock, the question of mineral deficiency was now taken so much into account that salt mixtures had been placed on the market which were said to supply all the essential minerals. But, though the addition of these might be beneficial in some cases, in others they might be actually supplying additional minerals already in excess, and so do positive harm.

Soil Investigation at Aberdeen. George Newlands, North of Scotland College of Agriculture.—The glacial drift soils of the North-East of Scotland consist largely of granitic material, still showing many of the "fresh"

characteristics of the original minerals. A method of separating and identifying the important mineral groups has been developed aud applied to our local soils and to certain well-known English types. A study of the mineralogical composition of the soil affords a useful means of distinguishing certain soil type.

The Scottish soils examined belonged to the type in which the silicates are only partially weathered, and in which there are, therefore, considerable reserves of lime, magnesia, potash and soda. On the other hand, the English soils are of the profoundly weathered type, in which supplies of available bases are limited except in the finest fractions obtained by mechanical analysis. Data as to the physical, chemical and mineralogical properties of the soils of the North-East of Scotland are being accumulated with a view to the determination of soil types, and their classification and distribution throughout the area. The soil of Craibstone Experimental Farm is being examined in greater detail. In particular, such properties as "lime requirement" and "soil acidity," expressed in terms of hydrogen ion concentration, are being recorded and compared.

Drainage Investigations at Craibstone. Professor Hendrick, University of Aberdeen.—Comparatively little investigation has been made into drainage through the soil, except by engineers from the point of view of the water supply, yet drainage investigation is of importance in agriculture in relation to the fertility of the soil, the reactions which take place in the soil, the loss of manurial material from the soil and the question of unexhausted manure values. The only agricultural drain-gauges in Britain are those at Rothamsted. The Craibstone drain-gauges differ from those at Rothamsted in many important respects, and are being used to obtain information (1) of the relation of percolation and evaporation to rainfall: (2) of the amount of nitrogen taken up by the crop and lost in the drainage under different conditions; (3) of the amount of the different ash constituents taken up by the crop and lost in the drainage under different conditions; and (4) of the rate at which manures are lost from the soil. Figures and information in illustration of all these points were given.

In addition to the work of the large drain-gauges which enclose the soil in its natural condition, investigations are being carried on with small drainage tanks artificially filled with soil. More numerous experiments can be carried out with these to determine such questions as (1) the limiting power of the soil to fix or retain manurial substances; (2) the extent to which the nitrification of ammonia takes place in a soil free from carbonate of lime; (3) the effect of dressings of lime as oxide and as carbonate on the drainage of such soil, and on the bases which are washed from the soil by the drainage; (4) the rate at which, and the extent to which the ammoniacal nitrogen of dung and the nitrogen of liquid manure or urine is lost from the soil in the drainage. All these questions are receiving some attention. The investigation of (4) is of great and pressing importance in connection with the unexhausted value of dung and of feeding stuffs fed to farm stock. More drainage investigations are needed in this country under different conditions of soil and climate. Large drain-gauges should be built on experimental farms so as to measure the effect of differences in rainfall and soil on what is washed away in drainage.

Research at the Royal (Dick) Veterinary College is hampered by the circumstance that ordinary routine teaching occupies nearly all the time of the members of the staff. Nevertheless, in spite of difficulties, a certain amount of research is accomplished. Recently, Dr R. Stewart Macdougall has conducted an inquiry within the College on anaphylaxis and the warble-flies. Professor J. Russell Greig has also made a preliminary investigation into the association of the spores of *Tilletia tritici* and epileptiform convulsions in dogs, and has found the spores not only in the fæces of affected animals, but also in the small blood-vessels of the central nervous system in cases that have been subjected to post-mortem examination. The inquiry is to be continued. Mr T. Grahame is at present investigating the post-natal development of the stomach of the sheep—a subject that up to the present has received scant

attention. The histology of the oviduct of the hen is also being studied in detail, in the hope that further light may be thrown on the production of the egg.

Plant Diseases and Soil Investigations. Dr Lauder, Edinburgh and East of Scotland College of Agriculture.—Owing to the lack of an experimental farm, research work had been confined up to the present to laboratory experiments, With the recent purchase of Boghall Farm, however, the work at Edinburgh for the next few years would be concerned mainly with the development of the farm as an experimental station. Particulars were given of the lines on which it was proposed this development should proceed. Details of the investigations at present being undertaken by members of the chemical, botanical and bacteriological departments were also given.

Ox Warble Fly.—Dr R. Stewart Macdougall detailed the work of a committee formed under the auspices of the three Departments of Agriculture to investigate the best means of combating the Ox Warble Fly pest. Having referred to the importance of the subject, an explanation was given of the steps taken to find either a dressing which would prevent the flies laying their eggs on the animals, or an insecticide which would be cheap and easy to apply against the larva in its last stage on the back of the animal. Three dressings—tobacco powder and lime, derris, and a proprietary preparation named "Lethol"—were tested on a county scale in East Lothian. Tobacco powder and lime was found to be highly satisfactory and derris gave encouraging results. A sufficient number of cases was not tested with Lethol to make a general statement possible. Some particulars of the distribution and times of appearance of the two species of the fly were given, and reference was also made to the work done on the subject of anaphylaxis.

Bee Diseases. Dr John Rennie, Aberdeen University and North of Scotland College of Agriculture.—In addition to various temporary ailments, three distinct diseases of bees existed in this country, viz., Bee Paralysis, Nosema Disease, and Acarine Disease. The chief characteristics of each disease were noted. The most prevalent and harmful was Acarine Disease which was associated with the presence of the mite *Tarsonemus Woodi* in the bee's respiratory system. This parasite had been discovered in 99·4 per cent. of cases of diseased bees, representing over 1000 stocks, examined at Aberdeen during the past three years. It had also been discovered without exception in all bees examined which were labelled as having suffered from "Isle of Wight" disease. The progress of *Acarine Disease* was not necessarily rapid or eventually fatal. It was possible to keep the malady at a low level, obtaining at the same time profitable results from the apiary.

Animal Diseases Research Association. Professor S. H. Gaiger, Chief Investigator.—After reference to the history of the Association, the methods of work adopted by the investigators were described and some of the results which had so far been obtained were detailed. Diseases on which work had been done included Braxy, Scrapie, Lamb Dysentery, and Trembling in Sheep, "Grass Disease" in Horses, Mammitis and Abortion in Cows, Swine Erysipelas in Pigs, and Distemper in Dogs. Reference was also made to the importance to the farmer of research in animal diseases, and its value to the general community in view of the close connection which exists between diseases in animals and diseases in human beings.

"Grass Sickness" in Horses. Dr J. W. Tocher.—After referring to the fact that the disease was first diagnosed in 1909 by Messrs Spreull, Dundee, it was stated in what districts and during what months the disease chiefly occurred. The symptoms of the two types of the disease, the acute and the sub-acute, were described and it was stated that diagnosis must rest fundamentally on the paralysis of the palate. The differences in the post-mortem appearances of the two types were explained. From the gut and contents of the gut of acute cases, and from the spleen of sub-acute cases, there had been isolated the *bacillus botulinus* which had the power of producing a highly virulent toxin. The symptoms reproduced by this toxin were identical with

those found in grass sickness with the sole exception that, as death occurred very rapidly, there was no impaction to be found *post-mortem*. After indicating the effects of different artificial methods of producing the disease, it was suggested that the exciting cause of grass sickness was some dietetic or metabolic or other error. This appeared to be borne out by clinical observations. An anti-toxin prepared from known strains of the *bacillus botulinus* protected animals from the toxin produced from the bacillus. An anti-toxin was present in the blood of sub-acute cases, but not in acute cases because they died too rapidly.

Last year an attempt was made with some success to immunise horses with a toxin anti-toxin mixture prepared from known strains of the *bacillus botulinus*. A much more powerful anti-toxin mixture is now being used and the results, so far as present information went, have been highly satisfactory.

Wheat Bulb Disease. Professor James F. Gemmill, University College, Dundee.—An account of Professor Gemmill's investigation into this disease appeared in the issue of *The Scottish Journal of Agriculture* for April, 1923.

Soil Survey Investigation. Matthew M. Monie, West of Scotland Agricultural College.—Emphasis was laid on the value of such work from an agricultural point of view, and a description was given of the survey which had been carried out in the Forth basin in Stirlingshire, special reference being made to the relation of the knowledge so gained to drainage, cropping and reclamation work.

Field Plot Technique. Professor J. A. S. Watson, Edinburgh University.—The technique adopted in carrying out field trials should not only give, in relation to the facilities available, the greatest possible degree of accuracy, but should enable the investigator to form a judgment regarding the degree of accuracy that has been attained in any particular case.

The ordinary amount of variation in field experiments is represented by a probable error of about 6 per cent. Variation may be usefully regarded as of two kinds—firstly, that which is due to the cumulative effect of pure accidents and, secondly, that which is due to definite variations in the land from one place to another. The extent to when the latter factor affects the results can be measured and corrected while the former cannot. An important factor in arriving at accurate results is the size of the plots laid out for experimental purposes. A single large plot will give a more accurate result than a single small plot, the probable error at Rothamsted being found to vary from 4·1 per cent. on a plot of $\frac{1}{500}$ acre to 2·1 per cent. on $\frac{1}{10}$ acre. Subdivision and replication of plots will give much greater accuracy than can be obtained from the same area divided into large plots. At Rothamstead, where there are no obvious variation in the land, the probable error was reduced to ·9 per cent. by utilising 20 plots of $\frac{1}{500}$ acre each. Where large and obvious soil irregularities exist, sub-division into a number of small plots gives very distinctly more accurate results than if the same area were divided into large plots, and in practice large plots should only be laid down where a large area of uniform land is available. Plots should be compared only with adjacent plots, and it is still better if the yield of each plot is compared with the mean of two standard or check plots, one on either side. The latter method can conveniently be carried out by placing check plots (of standard variety, manuring, etc.) alternately with the other trial plots, and it is calculated that under average field conditions the increase of accuracy is equivalent to that obtained by quadruplicating ordinary scattered plots, while being obviously more convenient. To secure any degree of scientific accuracy replication of the trial plots is necessary, the number of replications required depending upon the degree of accuracy aimed at. The probable error of the mean of any number of determinations is inversely proportional to the square root of the number of such determinations.

Mr T. Anderson, Director of the Seed-Testing Station of the Board of Agriculture for Scotland outlined the work being done for the purpose of obtaining information in connection with the administration of the Destructive

Insects and Pests Acts and Orders made thereunder, the Seeds Act and Regulations, etc. So far as potatoes were concerned, the work consisted of the testing of varieties and seedling varieties for immunity from Wart Disease, and experimental yield and maturity trials of varieties. Determinations of the distinctiveness of varieties and the recommendation of approved varieties for registration were the functions of a Synonyms Committee appointed by the Board. A method of grouping of characters had been formulated for use in connection with the schemes of registration and of inspection of potato varieties, and certification of pure stocks of immune varieties. An investigation into the degree of increase under Scottish conditions of the mosaic and leaf roll diseases was proceeding.

The testing of seeds was being conducted in accordance with established rules, and information as to strains of red clover and perennial ryegrass and the variation of botanical characters of various groups of popular types of oats was being collected as a preliminary to the operation of the plant registration scheme.

The Scottish Plant-Breeding Station. J. M. F. Drummond, Director.—The general methods of the work carried out at the Station, East Craigs, Corstorphine, might be summarised as :-

1. Collection and classification of suitable living material.
2. Isolation of pedigree strains.
3. Comparative trials of varieties or pedigree strains.
4. Hybridisation of pedigree strains, varieties or species.

A description of the work done under these heads was given. There were in cultivation at the Scottish Plant-Breeding Station approximately 500 types of cereals, 200 of potatoes, 300 of herbage plants, and 100 of swedes and turnips. Difficulty was experienced in classification owing to the almost entire lack of authoritative standard types. The isolation of pure lines in the case of a normally self-pollinated crop, such as oats, was a comparatively simple matter, but where both cross and self-pollination takes place naturally, as in swedes, the task is more troublesome. There were now in cultivation at the Station about fifty undoubted pure lines of oats, besides a number of pedigree strains of other crops.

Mr Drummond outlined the policy being followed and the objects aimed at in respect of oats, potatoes, herbage plants, turnips and swedes, and indicated the lines on which it was considered the work would require to proceed in order to obtain the best results.

Experiments in Butter-making. Professor R. H. Leitch, West of Scotland Agricultural College. The process of butter-making having been outlined, the controlling effect of the type of "starter" used and the manner in which it is employed on the quality of the finished product was pointed out. The advantages and defects of the types of "starters" in common use were detailed, and particulars were given of experiments with organisms comprised in the two great groups of lactic acid bacteria—the lactobacilli and the streptococcus cremoris. Representatives of the former group were found to be unsuited to butter-making, whilst the evidence obtained appeared to indicate that only selected members of the latter group were useful as starters in butter-making.

Experiments had also been carried out to obviate the loss of flavour due to washing granular butter in water, and it had been found that, by washing the granular butter with serum from ripened milk, butter was produced possessing a flavour and keeping properties distinctly superior to those of butter washed with water.

Other experiments described by Professor Leitch had reference to the effect of different Pasteurising Temperatures in Butter-making, the effect of Ripening to various degrees of acidity, and the addition of Milk Sugar to the butter on the worker.

RECENT PERIODICAL LITERATURE.

A number of the following extracts and summaries are taken from recent bulletins of the International Institute of Agriculture. Full references to the bulletins, and to the original publications quoted therein, may be obtained on application to the Secretary, Board of Agriculture for Scotland, York Buildings, Edinburgh.

The Importance of Magnesium as a Fertiliser. *Professor M. Popp and Dr J. Coutzen, Landwirtschaftliche Jahrbucher (Zeit schrift für wissenschaftlicher Landwirtschaft).*—Volcanic soils are mainly composed of silico-magnesian compounds. Magnesium is absolutely necessary to plants, for chlorophyll is an organic compound containing 2·7 per cent. of magnesium.

The author made some manurial experiments with magnesium from which he has drawn the following conclusions :—

The application of magnesian salts, in addition to different potassic salts, or of commercial potassic salts containing a certain amount of magnesium, does not materially increase the yield of different crops, although some good results have been obtained, but there were many cases of failure. Since the physiological reaction of the fertilisers is an important factor in crop yield, soil reaction must be taken into account as well as the reaction of the fertiliser. The potassic content of a plant depends upon the potassic fertiliser, but it is not, however, possible to tell from the amount of potash present in the plant whether enough potassic fertiliser has been applied. Indeed, it sometimes happens that a crop which has failed owing to lack of potash in the fertiliser has a higher potash percentage than a crop dressed with a potassic fertiliser. This is especially true in the case of grass, but may also occur in that of straw.

The amount of magnesium present in plants is little affected by a potassic fertiliser. The application of physiologically acid or alkaline magnesium salts has practically no effect on the magnesium content of the crop. Various plants use the magnesium of the soil to a different extent. Rye-grass assimilates most, then potatoes and tomatoes, and last of all rye, which assimilates very little of this element.

The solubility of the magnesium salts of mineral soils in a solution of ammonium chloride cannot be taken as any criterion of their assimilability by plants, for the values obtained from the solution are far too high. The potash of the soil is probably taken up at the same time as the magnesium, but larger amounts of the potash are utilised. The application of physiologically acid potassic salts has little effect upon the utilisation of the soil magnesium ; but physiologically alkaline salts may decrease it. Dressing with magnesian salts only influences the utilisation of potassic salts, in cases where physiological reaction comes into play. No direct action of the magnesium has yet been found. Salts of magnesium when added to a fertiliser are very little used by plants : the sole exception to this rule is in the case of the tomato, which bears a large number of leaves and absorbs considerable quantities of these compounds. The potato, on the other hand, utilises a magnesium fertiliser to a very limited extent, and therefore derives no benefit from it. The magnesium present in commercial potassic salts is not used differently. Neither the potato nor any other plant shows a preference for any special potassium salt.

Since the amount of magnesium present in the soil is certainly sufficient for the crops grown the application of magnesian salts seem superfluous.

The results of the author's experiments do not always agree with practical experience. Thus, for instance, for the beneficial effect on potatoes of the double sulphate of potassium and magnesium cannot be denied. It may, however, be supposed that the physiological reaction is of prime importance in this case. The problem can, however, only be solved by means of field experiments.

Cultivation and Animal Numbers. *H. M. Morris, Ann. App. Biol., Vol. ix., p. 282.*—A detailed investigation into the conditions of soils in

various states of cultivation has brought to light some interesting facts regarding the influence of intensive manuring upon the animal content of the soil. A comparison of two similar plots of land which had been subjected to different treatment was made at Rothamsted Experimental Farm. It was found that in a plot which had received no farmyard manure or fertiliser of any kind since 1839, there existed in the soil invertebrate animals to the number approximately of 4,950,000 per acre, and of these 2,470,000 were insects. But the contrast with a plot which had been treated annually since 1843 with farmyard manure at the rate of 14 tons per acre, was remarkable; for there the total number of invertebrates was about 15,100,000 per acre, and the number of insects amongst these was 7,720,000. It would seem that rich manuring by increasing the vegetable yield of the soil and so increasing its organic content had made available a food supply sufficient for an animal population much larger than that to be found in normal conditions.

Composition and Nutritive Value of Green Forage Silage. *Nils. Hansson, Kungl. Landtbruks Akademiens Handlingar och Tidskrift. Stockhom, 1922.*—The experiments with forage crops described in this publication in addition to the results noted in the *Comptes rendus de l'Institut Central de recherches agricoles* (No. 221) have led to the following conclusions:—

1. Leguminous forage crops and hay if silaged carefully form a valuable food for milch cows.

2. The most satisfactory results have been obtained with fresh green silage consisting of 30 to 50 per cent. leguminous plants cut when well matured, *i.e.*, when the pods are fully developed.

The forage should be well chopped up and stacked in such a way as to allow free circulation of air. The damping of forage, which contains a large amount of dry matter, owing to undue desiccation, and the watering of the upper layers in the silo, helps to exclude the air and encourages good fermentation.

3. The composition of the silage remains unchanged before and after ensilage. However, owing to moisture evaporation, the content of dry matter increases, and certain modifications take place in the composition of the nitrogenous and fatty content (ether extracts).

A large proportion of the albuminods are transformed into peptones and amino acids, and owing to their solubility, finally become changed into amides, retaining, however, their former value as albuminoids. Even in cases where fermentation took place under the best conditions, about 10 to 20 per cent. of the total nitrogen content of the forage was tranformed into ammonia and was consequently lost.

During fermentation in the silo, the sugar and the carbohydrates gave rise to considerable quantities of organic acids, partly fatty acids, lacking, however, the nutritive value of fats. Certain samples of silaged feed considered as quite satisfactory, possessed on analysis up to 1 per cent. free acids. On the other hand, the presence of butyric acid indicates a badly made silage.

4. Green silage has a favourable influence on milk production.

5. For milch cows the fresh silage forms an excellent winter feed, and may be used to substitute fresh fodder, at the rate of 15, 20 or 25 kg. or more per cow per day. Thanks to the high content of dry matter this may also serve to a certain extent to replace straw. The rich albuminoid content will permit also the making of meal cakes. Green silage, well turned, contains three to five times more albumin than the roots of forage crops.

6 Green silage has a dietetic value, and has a slight laxative effect.

7. Certain inconveniences are, however, associated with cheese-making, more especially in cases where full ripening is necessary. The cheeses made with milk from cows fed on silage often ferment to excess and exude a large amount of gas.

Ensilage Experiments in Germany. *H. Van Wenckstern, Deutsche landwirtschaftliche Presse.*—Under the direction of the "Okonomische Gesellschaft" at Dresden, feeding experiments have been in progress in

Saxony to test the value of forage silaged in various ways. The following results have been obtained :—

1. The conservation of forage by means of the electric current system (1), at present the most satisfactory method. This causes the minimum loss of dry matter and of albuminoid substance. It is especially suitable for green juicy forage, rich in albuminoids, as well as for plants otherwise not silaged easily owing to the excess of sap or moisture.

It is not, however, suitable for plants with a low moisture content. In this case and when the season is dry, and on small farms, the electric system costs more than the usual method of ensilage.

2. The improved compression system (the silo is filled by means of a suction-tube with chopped forage plants, which are spread and placed under heavy pressure ; the temperature then rises to 45° C.) provides forage which can be placed second on the list. This method is not advisable for fresh, juicy forage, or that which is soaked with rain. Under favourable conditions the electrical system is preferable.

3. The manual labour and compression method (filling the silo by manual labour with dried but not chopped material) is both difficult and inconvenient on small farms and with limited capital, where the silo is installed and worked by the owner and his family. On large farms it is only practicable where the farm hands are used to this work.

4. The turret silo (filled with material which may or may not have been dried and chopped, and then trodden under foot) ; this gives an acid silage, compared with that produced by the two preceding methods which give a sweet silage, and is, therefore, advisible for very moist material, which should not be subjected to the electrical process. As this method is undoubtedly easily worked, it is preferred on large farms to the sweet silage, that is to say, a fermentation mainly acid is preferred to one that is mainly alcoholic, although the latter is of more durable quality.

5. The inoculation method, with pure bacteriological cultures, is worth further study.

Arsenate of Sodium in Soil Sterilisation. *Gustave Rivière, Directeur de la Station Agronomique de Seine-et-Oise, and Georges Pichard, "préparateur chef" at the above Station, Annales de la Science agronomique française et étrangère. Paris, 1922.*—The author concludes from the results of his experiments that arsenate of sodium in small quantities (two or four gm. per square metre) has no injurious effects upon farm crops, but is sufficiently toxic to kill the protozoa which destroy the useful soil bacteria. Like other similar substances, sodium arsenate exercises indirectly a fertilising action.

Situation of Nitrogenous Fertilisers in France. *Camille Matignon, Annales de la Science Agronomique. Paris, 1922.*—This report, which was presented to the Interministerial Fertilisers Committee by M. Camille Matignon on behalf of the Sub-commission of Nitrogenous Fertilisers, examines successfully :

1. The amount of nitrogenous fertilisers required by France.
2. How far France, as compared with Germany, has been re-stocked with agricultural nitrogenous substances.
3. The productive capacity of the French nitrogenous fertiliser factories.
4. Method of developing the nitrogenous fertiliser industry.
5. The form in which combined nitrogen should be supplied for agriculture.

THE AMOUNT OF NITROGENOUS SUBSTANCES REQUIRED BY FRANCE.—In 1913 France produced 75,500 tons of sulphate of ammonia ; she imported sulphate of ammonia, nitrate of soda, calcium cyanamide and calcium nitrate.

Nitrogenous substances used in 1913 expressed as Nitrogen.

Sulphate of ammonia . . .	96,000 tons.
Nitrate of soda	320,000 ,,
Synthetic products . . .	15,000 ,,
	431,000 tons.

France thus required before the war about 70,000 tons of combined nitrogen annually.

Other things being equal, the nitrogen consumption of France was only about one-third and one-fifth of the amount used in Germany and Belgium respectively. The author is of opinion that the nitrogen placed at the disposal of the agriculturists should be trebled if the crops are to be increased to the required extent. This would bring the figure up to 200,000 tons, the minimum may be fixed at 140,000 tons.

During the agricultural year 1921-1922 France used 127,000 tons of sulphate of ammonia and produced 52,000 tons. She imported 260,000 tons of nitrate of soda, and manufactured some 12,000 tons of cyanamide for agricultural purposes. Expressed as nitrogen, the total consumption amounted to 69,000 tons, which is very near the pre-war figure, and it is probable that a state of equilibrium has not yet been attained.

In 1913 Germany used 200,000 tons of nitrogen, of which 60 per cent. was imported. From 1921-1922 she used 290,000 tons, all produced by her own factories. The output of the factories reached 500,000 tons by the end of 1922, hence she is now practically freed from all necessity to import Chili nitrate of soda, and will soon be in a position to export nitrates herself. Had Germany not been developing the industry of synthetic nitrogenous products since 1914, she would have been obliged to expend 400,000 million gold marks to obtain their equivalent in Chili nitrate.

At the present time there are in France factories for the following nitrogenous products :—

Sulphate of Ammonia from gas and coke works, night-soil, etc. In 1921, 51,400 tons were produced, as against 74,800 tons in 1913. It is hoped that the larger output will again be reached by 1924.

Cyanamide.—The French cyanamide industry can now fix 20,000 tons of nitrogen, and will be able to fix nearly 30,000 as soon as the new factories are complete.

Synthetic Nitrates.—The factories at present working turn out annually 1200 tons of nitrogen in the form of calcium nitrate.

The total annual nitrogen production of France amounts to 33,200 tons. As the minimum requirement is from 140,000 to 150,000 tons, there still remain 110,000 tons to be supplied by synthetic processes.

The Food of Moles. *F. L. Hisaw, Journ. of Mammology, 1923, p. 9.*—At the Agricultural Experiment Station of Kansas observations have been made on the feeding habits of moles. They have been found to be predominantly carnivorous, but even when fully supplied with insects and worms they yet eat a certain amount of vegetable matter, such as seeds. Wheat and oats are little eaten, but Indian corn is readily devoured, as also are tomatoes, apples and potatoes. Of the most usual foods certain distinct preferences were observed : these in order of merit may be placed earthworms and white grubs, insect larvæ other than white grubs, adult insects, maize, ripe tomatoes, and Irish potatoes and apples.

The average daily food consumption was 32·08 per cent. of the body weight of the animal ; but a mole was found to be capable of devouring 66·6 per cent. of its own weight in eighteen hours. Even on a diet largely vegetarian, consisting of potatoes and apples, with fresh beef only every second day, moles were found to be able to maintain their body weight. The author states that moles capture and kill active prey either by crushing it against the sides of the burrow with their fore paws, or by piling loose earth on it and biting it while it is thus held fast. He concludes that "the mole, perhaps, does more good than harm in uncultivated areas by destroying quantities of injurious insects, but in cultivated fields it is decidedly harmful."

Means of Controlling Diarrhœa and Arthritis in Foals. *G. H. Conn, Live Stock Journal, 1923.*—Two diseases causing many deaths among young foals are diarrhœa and arthritis.

A foal suffering from diarrhœa begins by taking less milk from its dam

is low spirited and has a slight fever. Then actual diarrhœa soon sets in; sometimes this gradually becomes worse and the animal evacuates with difficulty a watery liquid which is at first yellowish and afterwards greyish, being frequently streaked with blood and emitting a disagreeable odour. If the diarrhœa persists, the foal becomes weak and loses flesh; in most cases, however, the animal recovers.

The first thing to be done is to regulate carefully the ration of the dam and to give her every attention. If the indisposition is not serious at the beginning and is clearly due to the bad feeding or neglect of the dam, the foal must be given three or four times a day a spoonful of equal parts of phenyl-sulphite of zinc and soda dissolved in a little water, or else ten to fifteen drops of formalin two or three times a day dissolved in a pint of milk. This remedy is often called formaldehyde.

Foal arthritis is a contagious disease usually appearing during the first two days after birth, and never later than the fourth week after birth.

It is generally characterised by a swelling of the joints which are full of pus. Infection takes place by means of the umbilical cord which in these cases shrinks less rapidly than usual. The navel is slightly swollen and is hot to the touch. The foal does not run about much, or moves with difficulty; it has no wish to suck and has slight fever. In some cases, if the disease is treated at the outset, the animal makes good progress, but at other times the symptoms become more serious and the disease is characterised by general blood-poisoning, when the veterinary must at once be called in. Frequently, however, this serious form can be prevented by taking great care of the mare, lodging her well, and properly treating the umbilical cord of the foal as soon as the latter is born. The umbilical cord should neither be knotted nor tied, but antiseptically treated and made to dry up as quickly as possible. This can be done by dressing it with formalin every fifteen minutes for three to four hours, after which the cord is dry and there is little danger of any infection.

The umbilical cord may also be treated with iodoformed collodion three or four times in the course of the first day, or with tincture of iodine. The disinfection must be done thoroughly and with care.

The Effect of the Age of Cows and the Duration of the Lactation Period upon Milk Yield. *J. Wilson, The Scientific Proceedings of the Royal Dublin Society, 1922.*—The author first criticises: (1) the data furnished regarding the cows that competed at the London Dairy Show during the twelve years previous to 1909; (2) the data supplied by Garvin, who based his returns on the yield of dairy cows belonging to Lord Rayleigh in Essex (England); (3) Miner and Tocher's data, elaborated by Dr R. Pearl and obtained from the statistics published by the Scottish Milk Records Committee on the subject of the yield of Ayrshire cows from 1903 to 1912.

After explaining why the information given by the latter investigators does not help in determining the average effect of the age of a cow upon its milk yield, the author draws the following conclusions from the two first-named sources:—

1. Taking the yield of a cow of 8 years of age as 100, at the ages of 4—5—6—7 years, it will be respectively 67—80—90—95 and 98.
2. No sufficient data are available to ascertain the milk yield of two-year-old cows. According to the two above-mentioned sources, the milk yield of cows at the age of 2½ years would appear to be 50.
3. No figures can yet be given as to the milk yield of cows that are more than 5 years old.

Generally, the amount of milk produced by a cow during the lactation period is recorded, but since lactation periods are not always of the same length, it is necessary in instituting comparisons to know the amounts that must be added or subtracted from the total yield of one lactation period in order for it to have the value of an ordinary lactation. A normal yield is the yield estimated for a lactation period of 12 months. According to the data furnished for Ayrshire cows, for the year 1920, an 11 months' lactation period includes on an average 38 weeks of milk production, while in lactation periods

of 12, 13, 14 and 15 months, milk production goes on for 40, 42, 44 and 47 weeks respectively. These data enabled the author to complete the report of Garvin, who only continued his observations up to the 37th week of milk production. Garvin found that the milk yield of cows that had been re-mated began to decrease from the 24th week preceding calving.

Taking into account the date at which the milk yield decreases, the following figures were obtained for the lactation periods of different lengths:—in order to obtain the normal yield, 90 litres must be added to the actual yield in the case of an 11 months' lactation period, while 157, 292 and 405 litres must be subtracted from the yield of lactation periods lasting respectively 13, 14 and 15 months. These data are confirmed by the Ayrshire cow returns for 1913, 1919 and 1920, which have been published by the Scottish Milk Records Committee.

A Case of Twinning in Dairy Cattle. *C. C. Hayden, Journal of Heredity. Washington*, 1922. At the Ohio Agricultural Experiment Station a pure bred Holstein-Friesian cow has produced twins five times out of seven, and it appears that she comes from a prolific family, also given to bearing twins. This breed is noted as a good producer of milk and butter fat.

It has been suggested that a breed could be obtained which would produce a high percentage of twins, but the high proportion of males to females in the sets and the sterile nature of the latter makes the result of doubtful value.

The Preservation of the Purity of Milk. *P. de Montcault (Membre de l'Académie l'Agriculture), Journal d'Agriculture Pratique. Paris, 1922.*—The handling to which milk is now subjected exposes it to frequent contact with the air, and to risks of contamination. In order to keep the milk pure, some farmers sell it in bottles, but this is very expensive; the author, therefore, suggests another method which has all the hygienic advantages of bottling and costs less. Any such process must be based on the following principles:—(1) The substitution of asepsis for pasteurisation or sterilisation. Bacteria develop more rapidly after a certain lapse of time in pasteurised than in untreated milk. Chilled milk, on the other hand, resists bacterial contamination for a longer time; (2) a uniform sale price must be fixed for the whole year. If the milk were sold under a special mark, the public might be induced to pay the same price in summer as in winter.

In order to prevent the milk coming into contact with the air, the author suggests that it be poured, immediately after it is drawn from the cow, into tins in which the cover is replaced by a valve. This arrangement would enable the milk to be cut off from all contact with the outer air on entering the tin. The milk would be taken to the consumer in the same tin.

The author suggests that the apparatus used to supply motor spirit in the street could be adapted to prevent milk being poured into various receptacles, and thus running the risk of contamination during its distribution to the customers.

In consideration of the purity of the milk the public would be willing to pay the extra expense involved, while the increased receipts would compensate the producer for being unable to skim any of his milk.

The Association for the Sanitary Control of Milk in Seine-et-Oise (France). *Journal d Agriculture Pratique. Paris, 1922.*—This Association tests the milk intended for public consumption. The control exercised is optional; any agriculturist wishing to avail himself of the services of the Association sends in a request, on receipt of which the Commission pays a visit to his farm, and if it is found to be well-organised and equipped, and also in a satisfactory condition from the standpoints of cleanliness and hygiene, the owner's application is accepted.

In order to obtain sanitary control and the advantages accruing from it, dairy farmers must give a written assurance testifying to their willingness to comply with certain conditions of which the following are the chief:—

No tuberculous cow must be retained on the farm. All the dairy cows and any cattle that might contaminate them must be subjected, at least once a year,

to the tuberculin test. Any animals in which the reaction has been distinctly positive must be removed without delay. The doubtful cases are to be isolated and re-examined.

No new cow may be introduced into the cow-shed till it has been pronounced by the veterinary to be perfectly healthy in every respect.

The veterinary must also examine all the dairy cows at least once in three months. Any animal showing suspicious symptoms is to be isolated and subjected to a further test.

Persons suffering from a disease that can be transmitted by means of milk shall not be employed on the dairy farm.

The farmer shall not sell without a guarantee from the Departmental Agricultural Office, any milk that has not been produced under the above-mentioned conditions.

The farm shall be subjected to the milk control of the Departmental Service and organised by the Stock-Breeding Committee of Seine-et-Oise.

Farmers that have been accepted by the Control Commission and the Departmental Agricultural Office on the above-stated conditions are authorised to sell their labelled "Whole milk" (*Lait intégral*) which vouches that the product is clean and wholesome aud comes from a farm under the control of the Departmental Agricultural Office of Seine-et-Oise.

The working expenses of the control service are defrayed by the Departmental Agricultural Office and the dairy farmers interested.

Effect of Removing the Butter-Milk upon the Rancidity of Butter. *Chr. H. Ostesurt Smør. Ibsen, Beretning fra Forsøgslaboratiet. Copenhagen, 1921.*—From the results of the experiments made by Orla Jensen, and of those conducted in the experiment laboratories, the following conclusions have been reached.

Butter with fat granules 2-8 mm. in diameter after it has been thoroughly freed from butter milk, contains 22 per cent. less casein and 37 per cent. less lactose than butter that has not been similarly washed. Butter made from much fermented cream and moderately washed contains less casein than butter that has been but little washed. Thus, during the autumn it is advisable to let the cream ferment well, in order to prevent the butter turning rancid.

Given a moderate amount of washing, autumn butter composed of large granules will be inferior in quality to butter with granules 2 3 mm. in diameter.

If, during the hot months, butter is churned in such a manner that it can be well washed, its quality will be better after this treatment than that of butter from which the butter milk has been less thoroughly removed. Therefore, in the warm season, and especially in August and September, the acidity of butter and the consequences to which it gives rise, can be prevented effectually by the simple means of thorough washing.

Destruction of Cheese Mites. *E. R. de Ong and C. L. Roadhouse in Bull. 343, California Stn.*—In all parts of the world, wherever cheese is manufactured and kept, cheese mites seem to abound, devouring the substance of the cheese and damaging it still more in appearance and in saleability. If cheese must be kept it should be placed in cold storage at a temperature of 30° to 36° F., which prevents the activities of the pest; but if cold storage is not available then the cheese ought to be marketed in fresh condition. Perhaps, next best to cold storage in preventing an attack is the application of a coat of paraffin wax. When mites have once gained entry to a cheese, however, quite different methods have to be adopted. The simplest and most effective is the fumigation of the infested cheeses or rooms with either hydrocyanic acid, gas or carbon disulphide. Thorough fumigation should be immediately followed by as thorough cleaning of the rooms and prompt removal of all old cheese. Although the mites are destroyed the cheese seems to suffer no harm by this treatment; it absorbs none of the gas, it loses the unpleasant odour of the fumigant after a short exposure in the air, and has no objectionable taste or smell two hours after exposure in air. The vapour of burning sulphur in an infested room killed some. but not all of the mites.

Contagious *Ecthyma* of the Lips in Sheep. *G. Mousson, Journal d'Agriculture Pratique. Paris, 1923.*—The author describes the disease in its various forms, and the type of animals it attacks and also discusses the pathogenetic causes and the most suitable name for the infection. The conclusions he has arrived at respecting the malady are as follows: Contagious ecthyma is due to seasonal conditions and a specific agent. It is spread by direct and by indirect contact, frequently by means of food and drinking water. Diseased lambs can convey the infection to the teats of the sheep suckling them.

The best means of controlling the malady is the inoculation of all uninfected animals, as immediate isolation of the first cases is usually of little use, and separating the sheep when the disease has once taken hold of the flock prevents it from spreading so quickly, but does not eradicate it. Inoculation is effected with virulent matter taken from a sheep in which the eruption has been well developed. This lymph is mixed with sterilised water, or water and glycerine, so as to obtain a homogeneous emulsion. The healthy sheep are inoculated by two or three punctures on the inside of the ear, or on the inner surface of the thigh, which treatment causes them no inconvenience or general disturbance: they lose no flesh, and no complications ever arise.

A fortnight after inoculation all traces of its effects have disappeared.

The author made some inoculation experiments of this kind last summer with very satisfactory results. He is of opinion that inoculation should be carried out, even when all the sheep of a flock must be regarded as infected, and some of the cases have proved fatal. Inoculation ought to be effected as soon as the first well-characterised pustules make their appearance. When the eruption has once broken out on the animal's lips, the only thing to be done is to apply an antiseptic oil two or three times, which softens the crusts and causes them to fall without bleeding. The cure is much hastened by antiseptic dressings and the application of iodised glycerine.

Stomach Worm in Lambs. *C. Curtice, Journ. Amer. Vet. Med. Assn., 1922, p. 529.*—Experience of tests made throughout a period of five years enables the author to say that he has found the administration of bluestone solution to be the only satisfactory and practical means of controlling stomach worms in sheep. The stock solution consists of 1 lb. coarsely powdered copper sulphate solution dissolved in 2 quarts of boiling water, and 4 oz. of the stock, added to 3 quarts of water, suffices to doze twenty-five sheep, each of which (weighing 80 lbs. or over) receives 4 oz. of the dilute solution. Sheep should be dosed once a month throughout the year, but unweaned lambs or ewes within two weeks of lambing should not be treated.

Studies on Swine Feeding. *W. Spöttel and E. Tänger, Zeitschrift für Schweinezucht. Neudamm,* 1922.—THE AMOUNT OF CALCIUM AND OF PHOSPHORUS ANHYDRIDE NECESSARY FOR SWINE AND TO BE INCLUDED IN THEIR RATION.—The authors give a detailed account of all that is at present known on the subject, and of the experiments which have been made. It appears that the addition of organic and inorganic calcium compounds is necessary when the natural food of the animals is deficient in these substances which not only promote skeletal growth, but also metabolism and the constructive processes. If the rations contain sufficient calcium, no more need be added.

Bracken as Pig Food. *Jour. Roy. Soc. Arts, July* 1923.—It is well known that in past time extensive use was made of bracken "roots" or rhizomes for feeding purposes, and Mr L. M. Douglas advocates the fresh use of this material for the nourishment of pigs in Scotland. The method deserves a thorough trial, for in many areas the spread of bracken has proceeded apace in recent years to the destruction of hundreds of acres of sheep pasture; and a means at once of destroying and of utilising bracken would prove of inestimable value. Furthermore, the method seems to be a

reasonable one, for in Tasmania it has been successfully followed for many years. Pigs are put on fenced areas carrying bracken fern, where they should be allowed plenty of water and enough food to keep them going. In one instance, however, they throve so well on the bracken that the additional food supply was cut out. In the opinion of the Tasmanian Secretary for Agriculture, breeding sows between litters cannot be doing better than rooting ferns.

Fur Farming in Canada. *Jour. Roy. Soc. Arts*, 1923, *p.* 499.—A notable extension of the farming of fur-bearing animals is taking place in Canada. On 31st December 1921, the numbers of such animals amounted to 22,455 as against 16,529 on the corresponding date of the previous year; the respective values being $5,775,095 as against $4,722,905. The silver fox, patch fox and red fox constitute the majority of the farmed animals, their numbers in 1921 being 19,025. It would appear that, on the whole, the maritime provinces predominate in fur farming, Prince Edward Island alone having fox farms to the number of 359.

OFFICIAL ORDERS AND CIRCULARS.

The following notices were issued recently by the Board:—

Potato Varieties.

THE Board have prepared a list of names of all known varieties of the potato (together with their synonyms) which indicates, where known, whether the varieties are immune from or susceptible to wart disease. The list comprises over 1300 names and should prove of value to potato growers and merchants. Copies, price 2s. 6d. each, post free, may be had on application to the Secretary, Board of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh.

The Maintenance of Pure and Vigorous Stocks of Varieties of the Potato.

LEAFLET M.P. No. 3.—This leaflet (revised and greatly enlarged) which is intended for use as a handbook by potato growers and farmers to enable them to distinguish varieties and to keep stocks in a pure and healthy condition, contains comprehensive notes on the distinguishing characteristics of the tuber, stem, foliage, and flower of the potato, with illustrations. Emphasis is laid on the correlation existing between the colour of the sprout of the tuber and the colour of the flower.

The method of classification of varieties is fully explained. The most frequently occurring "rogues" are enumerated and hints are given on the handling of stocks to prevent mixing.

Full descriptions are given of some sixty-seven commonly cultivated varieties with full comparative descriptions of the rogues usually found in each variety.

These descriptions are couched in such terms as to enable a practical grower to identify readily any impurities in his stocks. An account is given of the common diseases of the potato particularly the foliage diseases (mosaic and leaf roll), which have been of late years attracting much attention as the principal cause of deterioration of varieties, and the chief considerations in maintaining healthy stocks are indicated.

The last portion of the leaflet, devoted to a guide to potato breeding and selection, which, *inter alia*, details the essential features which make for success in a commercial variety, should be carefully studied by all who are interested in potato breeding.

The leaflet can be obtained from the Secretary, Board of Agriculture for Scotland, York Buildings, Queen Street, Edinburgh, 1s. post free.

STATISTICS.

PRICES of AGRICULTURAL PRODUCE and FEEDING STUFFS in June, July and August 1923.

AVERAGE PRICES OF LIVE STOCK IN SCOTLAND.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	June. 1st.	June. 2nd.	June. 3rd.	July. 1st.	July. 2nd.	July. 3rd.	August. 1st.	August. 2nd	August. 3rd.
FAT STOCK :—									
CATTLE—	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.	per cwt. l.w. s. d.
Aberdeen-Angus .	68 4	62 5	45 2	68 10	62 10	44 6	66 5	60 5	41 3
Shorthorn	...	...	...	...	...	...	...	...	...
Galloway	63 3	57 3	..	60 7	54 9	...	57 4	52 7	...
Ayrshire	59 9	48 0	41 6	59 6	46 0	39 6	56 10	44 10	38 0
Cross-bred	64 6	59 1	41 11	64 1	58 3	40 3	61 3	55 5	37 8
Blue Grey	...	..	...	...	...	...	...	...	...
Highland	...	...	...	...	...	.	...	...	...
	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
VEAL CALVES	18	8	6	16	7	5	15	7	5
SHEEP—	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds. per lb. d.	Ewes per lb. d.	under 60 lb. per lb. d.	60 lb. and upw'ds per lb. d.	Ewes per lb. d.
Cheviot ...	17½	16¾	14¼	16	15	13	15¾	14¼	12½
Half-bred	17¼	16½	12¾	16¼	15	11¾	15¾	14¼	11
Blackface	17	15¾	13¾	16	14½	12¾	15½	14	11¾
Greyface	17¼	16	10½	16½	14¾	9½	15¾	14¼	9½
Down Crosses ...	17¾	16¾	...	16	14½	..	15½	14¼	...
PIGS—	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.	per stone. s. d.
Bacon Pigs	11 11	10 2	7 1	10 10	9 3	6 2	10 10	9 3	6 0
Porkers	12 4	10 7	7 0	11 6	9 9	6 2	11 5	10 6	6 2

Average Prices of Live Stock in Scotland—*continued.*

Description.	June. 1st.	June. 2nd.	June. 3rd.	July. 1st.	July. 2nd.	July. 3rd.	August. 1st.	August. 2nd.	August. 3rd.
STORE STOCK :									
Store Cattle—	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head. £ s.	per head £ s.	per head. £ s.
Aberdeen-Angus :									
Yearlings	20 4	16 3	13 1	20 8	16 1	12 1	20 8	16 9	14 12
Two-year-olds ...	28 2	23 0	19 4	26 10	22 6	18 14	28 11	23 13	...
Shorthorn :									
Yearlings	13 10	10 10	7 10	.	...	...	...	...	...
Two-year-olds ...	20 5	16 10	12 0	...	..	...	...	...	...
Galloway:									
Yearlings	16 14	...	...	14 6	.	...	15 6	...	...
Two-year-olds ...	27 15	...	...	23 10	19 18	...	..	20 5	...
Ayrshire :									
Yearlings	11 19	...	...	12 16	11 0	5 10	..	.	...
Two-year-olds . .	...	...	...	23 0	18 0	12 0	...	...	...
Cross-bred :									
Yearlings	17 14	14 17	11 2	17 9	14 10	10 17	17 10	14 11	11 7
Two-year-olds ...	26 3	21 18	18 12	25 5	21 3	18 0	23 19	20 7	18 0
Blue Grey :									
Yearlings	...	...	...	...	...	...	.	...	...
Two-year-olds ...	..	...	.		...	...	...	...	..
Highland :									
Yearlings	9 12	7 8	5 13	8 13	7 7	5 2	8 5	7 0	5 15
Two-year-olds ...	17 0	14 0	12 3	14 10	12 2	10 7	14 5	12 10	...
Three-year-olds ...	23 10	20 10	18 15	23 0	14 12	16 0	...	...	...
Dairy Cows—									
Ayrshire :									
In Milk	32 4	23 15	15 0	32 16	24 11	15 9	33 9	26 1	16 7
Calvers	31 1	24 4	15 16	32 15	24 15	16 4	34 13	26 7	16 14
Shorthorn :									
In Milk	33 11	25 18	21 3	37 10	26 8	21 10	34 7	26 11	21 7
Calvers	33 15	25 7	18 5	35 9	25 18	18 12	35 9	26 15	19 12
Store Sheep—	s. d.	s. d.	s. d.	s. d.	s d.	s. d.	s d.	s. d.	s. d.
Cheviot Hoggs ...	59 9	52 11	38 7	49 0	44 0	40 0	48 6	...	...
Half-bred Hoggs ...	85 3	63 0	57 0		...	61 3	74 6	61 6	...
Blackface Hoggs ...	48 7	39 5	31 10	44 10	38 5	28 9	41 0	39 9	25 6
Greyface Hoggs ..	65 6	51 7	42 0	62 3	51 8	45 3	67 9	50 9	...
Down Cross Hoggs	...	68 0	...	...	...	...	...	...	...
Store Pigs—									
(6 to 10 weeks old)	53 8	38 10	...	42 7	29 7	...	37 4	24 3	...

Average Prices of Dead Meat at Dundee, Edinburgh, and Glasgow.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	Quality.	June. Dundee.	June. Edinburgh.	June. Glasgow.	July. Dundee.	July. Edinburgh.	July. Glasgow.	August. Dundee.	August. Edinburgh.	August. Glasgow.
		per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.	per lb. d.
Beef:—Home-fed—										
Bullock or Heifer ..	1	10	10¼	11½	10	10¼	10⅝	9⅝	9⅞	10⅝
	2	9⅝	9½	9⅞	9¾	9⅜	8⅞	9	9	9⅜
Bull	1	8⅛	8⅝	8⅞	8⅛	8⅝	7⅜	8⅛	8¾	7⅜
	2	7¾	8	7½	8	8⅛	6⅜	7¾	8	6¾
Cow	1	7½	7½	8⅛	7⅜	6⅞	6⅞	6¾	6¾	7¼
	2	6½	6½	6⅝	6½	6	5⅞	6¼	5⅛	5¾
Irish—Bullock or Heifer	1	...	..	10⅛	...	...	9⅜	...	.	9⅜
	2	...	...	9⅝	...	...	8⅜	. .	...	8½
Bull	1	...	...	7¾	...	...	6⅞	...	...	7⅛
	2	...	...	7⅛	...	...	5⅞	...	...	5⅝
United States & Canadian—										
Killed at Birkenhead	1	...	...	10	...	...	...	...	..	...
	2	...	...	9½	...	...	...	...	...	...
,, Glasgow ...	1	...	...	10⅛	...	...	9½	...	...	9½
	2	...	...	9½	...	...	8½	...	...	8⅜
Argentine Frozen—										
Hind Quarters ...	1	...	6	5½	...	5⅞	5½	...	6	5½
Fore ,, ...	1	...	3¼	3⅞	...	3⅜	3¼	...	3¼	3¼
Argentine Chilled—										
Hind Quarters ...	1	...	7	7⅛	..	7¼	7¼	...	6⅜	7
	2	...	...	6⅝	...	...	6¼	...	...	6¼
Fore ,, ...	1	...	3⅝	3½	...	3⅝	3⅞	...	3⅜	3½
	2	...	...	3⅛	..	..	3⅜	...	...	3
Australian Frozen—										
Hind Quarters ...	1	...	.	4⅞	...	...	5	...	...	...
	2	...	...	3½	...	...	...	...	...	...
Fore ,, ...	1	...	...	3¼	...	...	3¼	..	...	...
	2	...	...	...	...	...	...	...	...	...
New Zealand Frozen—										
Hind Quarters ...	1	...	...	...	...	..	5	...	...	5⅛
	2	...	...	...	...	...	...	...	...	...
Fore ,, ...	1	...	...	...	...	...	3½	...	..	3¼
	2	...	...	...	...	...	...	...	...	...
Mutton:—										
Hoggs, Blackface ...	under 60 lb.	16¼	15⅜	16¼	16½	15⅛	16	15¾	14¼	15½
	60 lb. & over	...	14⅜	14½	...	14¼	13⅞	15	14	13¾
,, Cross	under 60 lb.	16¼	15⅞	16¼	16½	15¾	15½	15¾	14¾	15¼
	60 lb. & over	...	14¾	14	...	14⅜	13⅜	15	14⅜	13¼
Ewes, Cheviot ...	1	14	11⅝	13⅜	14	11	13	12¼	10⅛	11⅜
	2	13	...	11⅝	13	...	11	10½	...	10⅞
,, Blackface ...	1	14	...	12¾	14	...	12	12½	...	11
	2	13	...	10⅝	13	...	9⅞	10½	...	9⅛
,, Cross	1	11¼	10½	9¾	11	9¾	9⅜	9	9½	9
	2	10¼	...	8¾	10	...	8⅞	8	...	8
Argentine Frozen ...	1	...	6	5¾	..	6¼	5⅞	...	6⅜	5⅞
	2	...	5⅝	5⅜	...	...	5⅝	...	..	5⅛
Australian ,, ...	1	..	...	5⅛	...	...	5⅜	...	. .	5⅜
	2	...	...	4½	...	...	4⅞	...	...	5⅛
New Zealand ,, ...	1	...	...	5⅞	...	...	6¼	...	...	5⅜
	2	...	...	5½	...	...	5¾	...	...	5⅜
Lamb:—Home-fed ...	1	22	17⅜	18⅛	18¼	15⅞	17⅛	16¾	15⅛	15⅛
	2	...	15½	15¼	17⅝	15	15⅜	16	14¼	14¾
New Zealand Frozen	1	...	11½	11⅝	...	11¾	11⅝	...	11⅞	11⅝
	2	...	...	10½	...	...	10⅜	...	...	10⅜
Australian ,, ...	1	...	...	9¾	..	...	9½	...	...	9½
	2	...	...	9	...	...	9	...	...	9
Argentine ,, ...	1	...	9½	...	...	9½	...	...	9⅜	...
	2	...	...	...	...	...	...	...	...	...

Average Prices of Provisions at Glasgow.

(Compiled from Reports received from the Board's Market Reporters.)

Description.		Quality.	June. s.	June. d.	July. s.	July. d.	August. s.	August. d.
Butter:								
Irish Creamery...	per cwt.	1	151	0	153	3	171	2
" " (Unsalted)	"	1	156	0	157	0	178	5
Danish	"	1	158	6	160	6	182	2
" (Unsalted)	"	1	168	9	170	0	192	10
New Zealand	"	1	162	6	164	0	184	2
Cheese:								
Cheddar	"	1	92	8	96	6	110	2
		2	...		93	4	107	10
Dunlop	"	1	92	6	96	6	105	0
		2	...		93	4	101	2
Canadian	"	1	95	9	96	6	107	7
New Zealand (Coloured)	"	1	98	0	99	3	114	0
New Zealand (White)	"	1	98	0	99	9	114	10
Bacon:								
Ayrshire (Rolled) ...	"	1	156	0	153	6	158	0
Irish (Green)	"	1	116	0	125	0	...	
" (Dried or Smoked)	"	1	131	0	137	0	...	
" (Long Clear) ...	"	1	136	6	134	0	136	0
Wiltshire (Green) ...	"	1	117	0	125	0	...	
" (Dried or Smoked)	"	1	131	0	137	0	...	
American, Long Clear Middles (Green)	"	1	86	0	86	0	88	5
American, Short Clear Backs	"	1	88	6	88	0	89	2
American, Bellies...	"	1	83	0	82	0	83	7
" Sides ...	"	1	75	3	75	0	78	0
" Cumberland Cut	"	1	74	3	75	0	81	7
Canadian, Sides ...	"	1	92	0	92	0	108	5
Danish, Sides ...	"	1	103	6	108	0	122	2

Description.		Quality.	June. s.	June. d.	July. s.	July. d.	August. s.	August. d.
Hams:								
Irish (Smoked)	per cwt.	1	193	0	190	0	193	2
American, Long Cut (Green)	"	1	96	0	98	6	114	0
American, Short Cut	"	1	87	3	99	3	113	2
		2	85	3	96	9	110	10
Eggs:								
Country	per doz.	1	1	6	1	6	2	3
		2	1	4	1	4	2	1
Irish	per 120	1	12	8	12	0	17	4
		2	11	11	11	4	15	11
" (Cold Stored)	"	1	...		...		16	6
		2	...		...		15	0
" (Duck) ...	"	1	12	11	11	3	15	5
		2	...		...		...	
Chinese	"	1	10	3	...		...	
		2	9	9	...		...	
Danish	"	1	14	0	13	4	18	0
		2	12	5	11	11	16	9
Dutch (Duck) ...	"	1	12	0	11	6	...	
		2	...		...		...	
French	"	1	11	0	...		...	
		2	...		...		...	
Lithuanian ...	"	1	...		...		13	6
		2	...		...		...	
Polish	"	1	10	5	9	2	11	0
		2	9	9	8	6	10	8
Russian	"	1	10	6	10	0	...	
		2	9	6	9	0	...	

AVERAGE PRICES OF POTATOES AT DUNDEE, EDINBURGH, AND GLASGOW.

(Compiled from Reports received from the Board's Market Reporters.)

Markets.	Quality.	First Earlies.	Second Earlies.	Late Varieties.			
				Red Soils.		Other Soils.	
				Langworthy.	Other.	Langworthy.	Other.
		per ton £ s. d.	per ton. £ s d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
		JUNE.					
Dundee ...	First	...	...	...	...	...	1 10 0
	Second	...	...	...	...	...	...
Edinburgh ...	First	22 0 0	...	...	4 10 0	...	2 5 0
	Second	...	...	...	...	...	...
Glasgow ...	First	22 10 0	...	7 15 0	4 7 6	6 15 0	2 8 9
	Second	...	...	...	...	...	...
		JULY.					
Dundee ...	First	12 13 4	...	...	...	...	1 10 0
	Second	9 5 0	...	...	...	...	...
Edinburgh ...	First	9 10 0	...	...	...	...	2 10 0
	Second	...	...	...	...	...	...
Glasgow ..	First	10 2 4	...	8 0 0	4 0 0	7 0 0	2 10 0
	Second	...	...	...	...	...	...
		AUGUST.					
Dundee ...	First	7 12 0	...	...	...	...	...
	Second	6 0 0	...	...	...	...	...
Edinburgh ...	First	7 12 0	6 15 0	...	...	...	...
	Second	...	...	...	...	...	...
Glasgow ...	First	7 0 5	6 13 0	...	...	...	...
	Second	...	...	...	...	...	...

Average Prices of Roots, Hay, Straw, and Moss Litter, at Dundee, Edinburgh, and Glasgow.

(*Compiled from Reports received from the Board's Market Reporters.*)

Markets.	Quality.	Roots. Carrots.	Roots. Yellow Turnips.	Roots. Swedes.	Hay. Rye Grass and Clover.	Hay. Timothy.	Straw. Wheat.	Straw. Barley.	Straw. Oat.	Moss Litter.
		per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton. s. d.	per ton s. d.	per ton. s. d.	per ton. s d.
JUNE.										
† Dundee ...	1	...	...	22 6	125 0	...	65 8	...	60 0	...
	2	...	...	...	106 11	...	...	...	...	...
‡ Edinburgh	1	...	...	...	107 6	...	41 3	...	41 11	...
	2	...	...	...	...	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	27 6
	2	...	...	...	...	...	...	...	...	...
JULY.										
† Dundee ...	1	...	...	...	121 3	...	75 8	...	72 6	...
	2	...	...	...	118 0	...	...	...	...	...
‡ Edinburgh	1	...	...	...	108 2	...	43 2	...	43 2	...
	1	...	...	...	90 0*	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	25 0
	2	...	...	...	...	...	...	...	...	...
AUGUST.										
† Dundee ...	1	...	18 0	...	120 0	...	70 0	...	69 0	...
	2	...	...	...	105 0	...	...	...	...	...
‡ Edinburgh	1	...	...	...	107 6	...	45 0	...	44 0	...
	1	...	...	...	84 0*	...	...	...	...	...
Glasgow ...	1	...	...	...	...	...	...	...	...	25 0
	2	...	...	...	...	...	...	...	...	...

† Quotations for Hay and Straw baled and delivered.
‡ ,, are for Hay and Straw delivered loose in town.
* New Crop.

Average Prices of Feeding Stuffs at Glasgow and Leith.

(Compiled from Reports received from the Board's Market Reporters.)

Description.	June.		July.		August.	
	Glasgow.	Leith.	Glasgow.	Leith.	Glasgow.	Leith.
	per ton. £ s. d.	per ton £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.	per ton. £ s. d.
Linseed Cake—						
Home	12 0 0	10 15 0	11 15 0	10 15 0	11 15 0	10 16 0
Foreign	10 18 9	...	10 15 0	...	10 15 0	...
Undecorticated Cotton Cake -						
Bombay (Home-manufactured)	7 0 0	6 10 0	7 0 0	6 10 0	7 1 0	6 9 6
Egyptian (Home-manufactured)	8 0 0	...	8 0 0	...	8 0 0	...
Coconut Cake ...	...	...	...	...	...	...
Groundnut Cake-Undecorticated ...	*9 15 0	*9 17 6	*9 11 3	*9 15 0	*9 5 0	*9 15 0
Maize Germ Cake	10 2 6	...	10 2 6	...	10 2 6	...
Maize Germ Cake Meal	10 12 6	...	10 12 6	...	10 12 6	...
Bean Meal ...	13 0 0	13 0 0	12 16 3	13 0 0	11 9 0	11 19 0
Maize Meal ...	10 16 3	10 15 0	10 15 8	10 15 0	10 16 0	10 15 0
Locust Bean Meal	...	7 5 0	...	7 5 0	...	7 5 0
Rice Meal.. ...	...	...	...	...	7 0 0	...
Maize Gluten Feed (Paisley)	9 10 0	..	9 10 0	...	9 10 0	...
Maize	†9 16 3	9 15 0	†9 15 8	9 15 0	†10 3 4	9 15 0
Oats, Canadian ...	9 11 11	...	9 7 2	...	9 1 0	...
„ Home ...	11 3 9	10 10 0	11 5 0	10 10 0	...	10 10 0
Barley (Feeding) ...	9 3 9	9 5 0	8 16 3	9 5 0	8 5 6	9 5 0
Malt Culms ...	6 17 6	...	6 15 0	...	6 15 0	...
Distillery Mixed Grains —Dried ...	8 4 5	9 0 0	8 1 11	9 0 0	8 0 0	8 0 0
„ Wet ...	...	1 15 0	...	1 15 0	...	1 15 0
Brewers' Grains						
Dried	7 3 2	7 10 0	...	7 5 0	...	6 17 6
Wet	...	1 12 6	...	1 12 6	...	1 12 6
Distillery Malt Grains Dried ...	7 13 2	...	7 12 6	...	7 12 6	...
Wheat—						
Middlings (Fine Thirds or Parings)	8 10 0	8 1 3	8 10 0	8 0 0	8 14 0	8 6 0
Sharps (Common Thirds)	7 0 0	6 17 6	6 18 9	6 15 0	6 14 0	6 17 0
Bran (Medium) ...	6 15 0	6 10 0	6 6 11	6 10 0	6 8 0	6 5 0
„ (Broad) ...	7 0 8	7 12 6	6 13 9	7 0 0	6 13 0	7 5 0
Feeding Treacle ...	7 0 0	6 5 0	6 15 0	6 5 0	6 11 11	6 10 [illegible]
Fish Meal... ...	14 12 6	15 10 0	14 5 0	15 10 0	14 5 0	15 5 [illegible]

* Oil and Albuminoids 40 to 42 per cent.
† American Corn.

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